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Cambridge Lower Secondary Mathematics

WORKBOOK 9

Lynn Byrd, Greg Byrd & Chris Pearce



Second edition

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Mathematics

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How to use this book

> How to use this book

This workbook provides questions for you to practise what you have learned in class. There is a unit to match each unit in your Learner's Book. Each exercise is divided into three parts:

- **Focus:** these questions help you to master the basics
- **Practice:** these questions help you to become more confident in using what you have learned
- **Challenge:** these questions will make you think very hard.

You will also find these features:

Words you need to know.



Key words

changing the
subject
subject of a
formula

Step-by-step examples
showing how to solve
a problem.



Worked example

FPO

These questions help
you to practice thinking
and working like a
mathematician.



TWM question

FPO

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> Acknowledgements

TBC

SAMPLE

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1

Number and calculation

> 1.1 Irrational numbers

Exercise 1.1

Focus

Key words

irrational number
surd

- 1 Copy this table. Tick (✓) the correct boxes.

Number	Rational	Irrational
$\sqrt{36}$		
$\sqrt{48}$		
$\sqrt{64}$		
$\sqrt{84}$		
$\sqrt[3]{100}$		

- 2 Look at these numbers:
 12.77 -36 $\sqrt{27}$ $\sqrt{500}$ $\frac{61}{12}$ $-\sqrt[3]{8}$

- a Write the **irrational numbers**.
 b Write the **integers**.

- 3 Write whether each of these numbers is an integer or a **surd**.
 a $\sqrt{25}$ b $\sqrt[3]{25}$ c $\sqrt{125}$
 d $\sqrt[3]{125}$ e $\sqrt{225}$ f $\sqrt[3]{225}$

- 4 Is each of these numbers rational or irrational? Give a reason for each answer.

- a $\sqrt{3} + 6$ b $\sqrt{3 + 6}$ c $\sqrt{64} + \sqrt[3]{64}$ d $\sqrt[3]{8} + \sqrt[3]{19}$

1 Number and calculation

Practice

- 5 a Find 1.5^2
 b Show that $\sqrt{2.25}$ is a rational number.
 c Is $\sqrt{20.25}$ a rational number? Give a reason for your answer.
 d Is $\sqrt[3]{1.331}$ a rational number? Give a reason for your answer.
- 6 Without using a calculator, show that
 a $3 < \sqrt[3]{41} < 4$ b $9 < \sqrt[3]{800} < 10$ c $1.1 < \sqrt{1.36} < 1.2$
- 7 Without using a calculator, find an irrational number between
 a 2 and 3 b 6 and 7 c 1.4 and 1.5
- 8 Without using a calculator, estimate
 a $\sqrt{140}$ to the nearest integer
 b $\sqrt[3]{350}$ to the nearest integer.
- 9 Arun says:

My calculator shows $2\frac{7}{81} = 2.086\ 419\ 753$ and this does not have a repeating pattern, so $2\frac{7}{81}$ is irrational.



- a Is Arun correct? Give a reason for your answer.
 b Do you think $\sqrt{2\frac{7}{81}}$ is a rational number? Give a reason for your answer.

Challenge

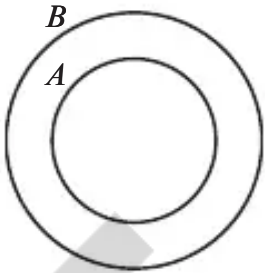
- 10 a Use a calculator to show that $\sqrt{2} \times \sqrt{32}$ is a rational number.
 b Find two irrational numbers with a product of
 i 6 ii 9 iii 10
- 11 a Find two irrational numbers with a sum of 5.
 b Explain why it is impossible to find two rational numbers with a sum of $\sqrt{5}$.
 c Is it possible to find two rational numbers with a product of $\sqrt{5}$? Give a reason for your answer.

- 12 This Venn diagram shows all the numbers on a number line.

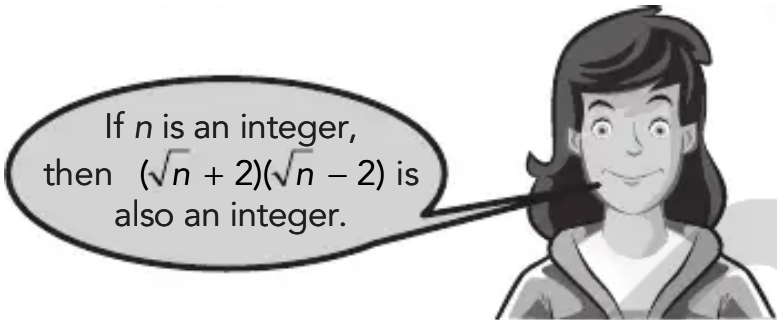
A is the set of integers. B is the set of rational numbers.

Copy the diagram and put each of these numbers in the correct place.

25 5.5 $5\frac{5}{11}$ $\sqrt{25}$ $\sqrt[3]{25}$



- 13 a If $n = 20$, find the value of
- i $\sqrt{n} + 2$ ii $\sqrt{n} - 2$ iii $(\sqrt{n} + 2)(\sqrt{n} - 2)$
- b Sofia says:



Is Sofia correct? Give some evidence to support your answer.

> 1.2 Standard form

Exercise 1.2

Focus

Key words
standard form

- 1 Write these numbers in **standard form**.
- a 2 600 000 b 920 000 000 c 462 000 d 20 800 000
- 2 Write these numbers in standard form.
- a 55 000 b 55 million c 640 million d 406 million
- 3 These numbers are in standard form. Write each number in full.
- a 5.3×10^4 b 5.38×10^7 c 7.11×10^{11} d 1.331×10^8
- 4 A light year is the distance light travels in one year.
One light year is 9 460 000 000 000 km.
Write this distance in standard form.

1 Number and calculation

Practice

- 5 Write these numbers in standard form.
- a 0.00003 b 0.000 000 666
c 0.0000505 d 0.000 000 000 48
- 6 These numbers are in standard form. Write each number in full.
- a 1.5×10^{-3} b 1.234×10^{-5}
c 7.9×10^{-8} d 9.003×10^{-4}
- 7 Write these numbers in full.
- a 8×10^{-6} b 4.82×10^{-7}
c 6.1×10^{-5} d 7.007×10^{-8}
- 8 The wavelength of visible light is between 0.000 000 4 m and 0.000 000 8 m.
Write each of these numbers in standard form.
- 9 Look at these five numbers.
A = 9.8×10^{-7} B = 1.2×10^{-6} C = 3.05×10^{-7}
D = 4.81×10^{-6} E = 5.17×10^{-7}
Write the numbers in order of size, smallest first.

Challenge

- 10 The mass of Earth is 5.98×10^{24} kg.
- a When you write this mass in full, how many zeros does it have?
b The mass of Mars is approximately $\frac{1}{10}$ of the mass of Earth.
Write the mass of Mars in standard form.
- 11 a Copy and complete this sentence:
 6.2×10^4 is times larger than 6.2×10^6 .
b How many times larger than 8.5×10^{-3} is 8.5×10^3 ?
- 12 These numbers are **not** in standard form. Write each number in standard form.
- a 45×10^6 b 28×10^8
c 300×10^4 d 995×10^7
- 13 Write each of these numbers in standard form.
- a 43×10^{-5} b 125×10^{-8}
c 0.7×10^{-5} d 0.08×10^{-7}

14 Do these additions. Give your answers in standard form.

a $8.1 \times 10^5 + 9.4 \times 10^5$

b $6.7 \times 10^7 + 6.7 \times 10^7$

c $3.6 \times 10^{-5} + 2.9 \times 10^{-5}$

d $2.86 \times 10^{-5} + 8.6 \times 10^{-5}$

> 1.3 Indices

Exercise 1.3

Focus

1 Write each number as a fraction.

a 7^{-1}

b 7^{-2}

c 5^{-3}

d 3^{-4}

e 15^{-2}

f 20^{-2}

2 Write these numbers as powers of 4.

a $\frac{1}{4}$

b $\frac{1}{64}$

c 1

d 256

e $\frac{1}{256}$

f 16^{-1}

3 Write each number as a power of 5.

a 0.2

b 25

c 0.04

d 125^{-1}

e 15^0

4 Find the value of x^{-3} when

a $x = 2$

b $x = 3$

c $x = 5$

d $x = 10$

Practice

5 Write the answer to each multiplication as a power of 12.

a $12^3 \times 12^{-1}$

b $12^4 \times 12^{-5}$

c $12^{-1} \times 12^{-2}$

d $12^{-4} \times 12^7$

6 Write the answer to each multiplication in index form.

a $5^4 \times 5^{-1}$

b $4^{-3} \times 4^{-3}$

c $8^{-6} \times 8$

d $15^5 \times 15^{-5}$

e $5^{-6} \times 5^{-6}$

7 Write the answer to each division as a power of 7.

a $7^5 \div 7^2$

b $7^3 \div 7^4$

c $7^4 \div 7^{-2}$

d $7^{-4} \div 7^{-3}$

1 Number and calculation

8 Write the answer to each division in index form.

- a $12^3 \div 12^{-2}$ b $5^{-5} \div 5^2$
c $3^4 \div 3^8$ d $25^{-3} \div 25^{-4}$

Challenge

9 Find the value of x in these equations.

- a $2^3 \times 2^x = 2^9$ b $3^2 \times 3^x = 3^{-2}$
c $5^{-3} \times 5^x = 5^{-5}$ d $8^x \times 8^{-3} = 8$

10 Find the value of y in these equations.

- a $3^2 \div 3^4 = 3^y$ b $10^6 \div 10^y = 10^2$
c $14^2 \div 14^y = 14^{-4}$ d $8^y \div 8^3 = 8^4$

11 $y = x^0 + x^{-1} + x^{-2}$

Find the value of y when

- a $x = 1$ b $x = 2$ c $x = 3$

12 This table shows powers of 11.

11^2	11^3	11^4	11^5	11^6
121	1331	14641	161051	1771561

Use the table to work out the following. Do not use a calculator.

- a 121×14641 b $1771561 \div 14641$ c $121 \div 161051$

13 Find the value of x in this equation: $2^3 \times 4^2 = 2^x$

2

Expressions and formulae

> 2.1 Substituting into expressions

When you substitute numbers into an expression or formula, you must use the correct order of operations. Work out brackets and indices first, then divisions and multiplications, and finally additions and subtractions.

Key word

counter-example

Exercise 2.1

Focus

- 1 Copy and complete the workings to find the value of each expression when $x = 10$.

a $2x + 3$ $2 \times x + 3 = 2 \times 10 + 3$
 $= \square + 3 = \square$

b $\frac{x}{2} - 4$ $x \div 2 - 4 = 10 \div 2 - 4$
 $= \square - 4 = \square$

c $4x^2$ $4 \times x^2 = 4 \times 10^2$
 $= 4 \times \square = \square$

d $3(x + 2)$ $3 \times (x + 2) = 3 \times (10 + 2)$
 $= 3 \times \square = \square$

Tips

Work out the multiplication before the addition.

Work out the division before

the subtraction. Work out the indices before the multiplication.

Work out the bracket before the multiplication.

2 Expressions and formulae

- 2 Match each expression, A to F, with the correct value, i to vi, when $a = 8$ and $b = 4$.

A $a + b$	B $a - b$	C ab	D $\frac{a}{b}$	E $\frac{b}{a}$	F $2a + b$
------------------	------------------	---------------	------------------------	------------------------	-------------------

i 32	ii $\frac{1}{2}$	iii 12	iv 20	v 4	vi 2
-------------	-------------------------	---------------	--------------	------------	-------------

Tip

Remember, ab means $a \times b$.

- 3 Copy and complete the workings to find the value of each expression when $x = 6$ and $y = -2$.

- a** $x + y = 6 + -2 = \square - \square = \square$
b $x - y = 6 - -2 = \square + \square = \square$
c $x^2 + y^2 = 6^2 + (-2)^2 = \square + \square = \square$
d $3x + y = 3 \times 6 + -2 = \square - \square = \square$
e $x + 4y = 6 + 4 \times -2 = \square - \square = \square$
f $3x + 4y = 3 \times 6 + 4 \times -2 = \square - \square = \square$

Tip

Remember:

$+- \rightarrow -$ and
 $-- \rightarrow +$

So:

$+ -2$ is overall -2
 -2×-2 is overall $+4$

- 4 Work out the value of each expression when $a = -3$ and $b = 5$.

- a** $a + b$ **b** $3a - b$ **c** $20 - ab$
d $a^2 + 4$ **e** $\frac{7b}{5}$ **f** $b^3 - 25$

Practice

- 5 Work out the value of each expression when $a = 2$, $b = -3$, $c = 4$ and $d = -5$.

- a** $a + 2b$ **b** $bd - 10$ **c** $4b + 2a$
d $ab + cd$ **e** $cd^2 + ab$ **f** $\frac{d}{2} - a$
g $20 - a^3$ **h** $\frac{bc}{a} + d$

- 6 This is part of Malik's homework.

Question

Work out the value of each expression when $x = -4$ and $y = -1$

a $xy^2 - 3x$

b $x^3 - \frac{x}{2y}$

2.1 Substituting into expressions

Answer

$$\begin{aligned} a \quad -4 \times -1^2 - 3 \times -4 &= 4 + 12 \\ &= 16 \end{aligned}$$

$$\begin{aligned} b \quad (-4)^3 - \frac{-4}{2 \times -1} &= 64 - \frac{-4}{-2} \\ &= 64 - 2 \\ &= 62 \end{aligned}$$

Check Malik's work. If he has made any mistakes, explain the mistakes he has made and write the correct solutions.



- 7 The expression $x^3 - y$ has a value of 20.
Write three pairs of integer values for x and y when

- a x and y are both positive numbers
- b x and y are both negative numbers
- c x is positive and y is negative, or vice versa.

Show all your working.

- 8 Work out the value of each expression when $w = 3$, $x = 2$, $y = -4$ and $z = -2$.

- | | | |
|-------------------------------|----------------------|------------------|
| a $3(w + x)$ | b $x(2w - y)$ | c $z(2w - y)$ |
| d $w - z^3$ | e $x^2 + z^2$ | f $(2z)^3$ |
| g $\frac{x}{2} - \frac{y}{4}$ | h $\frac{wx}{z} + y$ | i $2(x^3 - z^2)$ |
| j $20 - 2w^2$ | k $w + z(3x - 2y)$ | l $(3z)^2 - x^5$ |

Challenge

- 9 This is part of Sasha's homework.

Question

Use a **counter-example** to show that the statement $3x^2 = (3x)^2$ is not true ($x \neq 0$).

Answer

Let $x = 3$, so $3x^2 = 3 \times 3^2 = 3 \times 9 = 27$ and $(3x)^2 = (3 \times 3)^2 = 9^2 = 81$
 $27 \neq 81$, so $3x^2 \neq (3x)^2$

2 Expressions and formulae

Use a counter-example to show that each of these statements is not true ($x \neq 0, y \neq 0$).

- a $10x^2 = (10x)^2$

c $3x - 3y = 3(y - x)$
- b $(2y)^3 = 2y^3$

- 10 Here are two expressions that you can use to estimate the mass, in kg, of a child aged between one and five years old. A is the age, in years, of the child.

Expression 1

$$\frac{5A}{2} + 8$$

Expression 2

$$2(A + 4)$$

- a Use expression 1 to estimate the mass, in kg, of a 4-year-old child.

b Use expression 2 to estimate the mass, in kg, of a 3-year-old child.

c Copy and complete the table showing the estimates of the mass of a child using both expressions.

Age (A years)	1	2	3	4	5
Mass using expression 1					
Mass using expression 2					

- d Fasil is 3 years old and has a mass of 13.5 kg.
Which expression would give the best estimate for his mass?
Explain your answer.

- 11 Work out the value of each expression.

a $5(x^3 - x) + \frac{5x^2}{3} - 12x$ when $x = 3$

b $\frac{3y+16}{4} + \left(\frac{y}{2}\right)^4 - \frac{20}{y}$ when $y = 4$

- 12 Show that $4d^2 - \frac{100}{c^2} - 3cd - c(c - d) = d^3 + \frac{8c}{(c+d)^3} + \left(\frac{3c}{d}\right)^2 - (-4 - c^2)$
when $c = 5$ and $d = -3$.

> 2.2 Constructing expressions

In algebraic expressions, you use letters to represent unknown numbers. When you are asked to write an expression, think how you would write it with numbers first.

Exercise 2.2

Focus

- 1

Add 2 to each of these numbers. Show your working.
Parts **a** and **c** have been done for you.

a

4

$4 + 2 = 6$

b

10

.....

c

x

$x + 2$

d

z

.....
- 2

Subtract 3 from each of these numbers. Show your working.
- 3

Multiply each of these numbers by 5. Show your working.

a

5

2

b

8

4

c

y

a

d

z

b
- 4

Divide each of these numbers by 5. Show your working.

a

15

b

30

c

a

d

b
- 5

Match each statement with the correct expression.
The first one has been done for you: **A** and **iii**.
I think of a number n and...

A	I add 15
B	I subtract 15
C	I multiply by 15
D	I divide by 15
E	I subtract the number from 15
F	I multiply by 3 then add 5
G	I multiply by 5 then subtract 3
H	I divide by 5 then add 3

i	$15n$
ii	$3n + 5$
iii	$n + 15$
iv	$5n - 3$
v	$\frac{n}{5} + 3$
vi	$n - 15$
vii	$\frac{n}{15}$
viii	$15 - n$

Key word

in terms of

Tip

$4 + 2$ can be simplified to 6.

Tip

$x + 2$ cannot be simplified so leave it as $x + 2$.

Tip

You can simplify $a \times 5$ to $5a$.

Tip

You can simplify $a \div 5$ to $\frac{a}{5}$.

2 Expressions and formulae

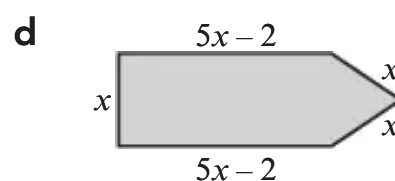
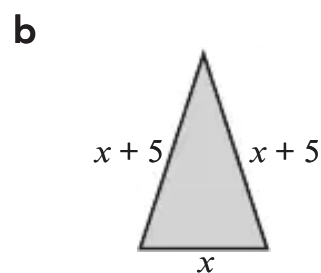
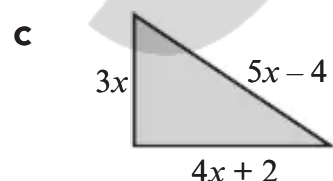
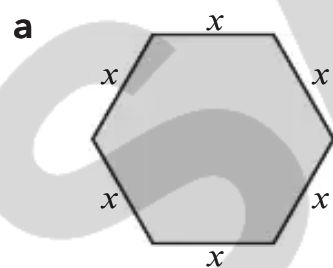
Practice

- 6 Zara thinks of a number, n .



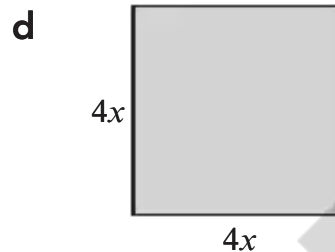
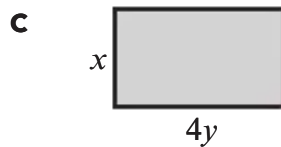
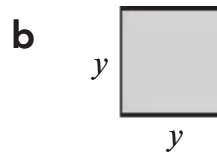
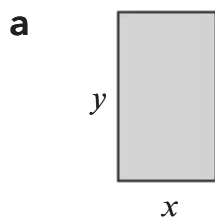
Write an expression, **in terms of n** , for the number Zara gets when she

- a adds 1 to the number
 - b subtracts 10 from the number
 - c multiplies the number by 100
 - d divides the number by 1000
 - e multiplies the number by 2, then adds 3
 - f divides the number by 4, then subtracts 5
 - g multiplies the number by 6, then subtracts 7
 - h divides the number by 8, then adds 9
 - i divides 1 by the number, then subtracts 1
 - j divides 10 by double the number
 - k adds 20 to the number, then multiplies the result by 3
 - l subtracts 3 from the number, then multiplies the result by 20.
- 7 Write an expression, in terms of x , for the perimeter of each shape. Write each expression in its simplest form.



2.2 Constructing expressions

- 8** Write an expression for the area of each shape.
Write each expression in its simplest form.



- 9** The diagram shows a triangle.

The lengths of the sides of the triangle are written as expressions.

- a** When $g = 5$, work out the lengths of the sides of the triangle.

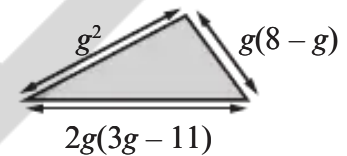
- b** Use your answers to part **a** to work out the perimeter of

- c** the triangle.
Write an expression for the perimeter of the triangle.

Show that the expression can be simplified to $6g^2 - 14g$.

- d** Substitute $g = 5$ into the expression for the perimeter in part **c**.

Check your answers to parts **b** and **d** are the same.

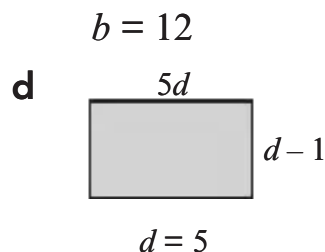
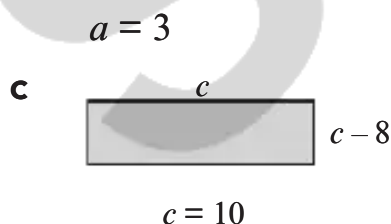
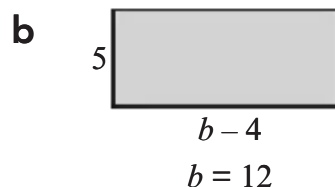
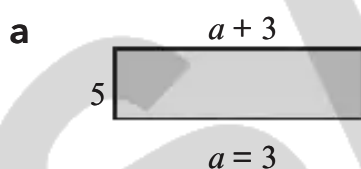


- 10** For each rectangle, write an expression for

- i** the perimeter **ii** the area.

Write each answer in its simplest form.

Use the values given, and the same method as in Question 9, to check your expressions are correct.



$c = 10$

$d = 5$

2 Expressions and formulae

Challenge

- 11 Jake and Razi have four different types of rod.

The length of each grey rod is $a + 2$.

The length of each black rod is $a + 3$.

The length of each white rod is $2a + 2$.

The length of each striped rod is $3a + 1$.

Jake shows Razi that the total length of two black rods and four striped rods is the same as the total length of four white rods and two striped rods, as shown.



$$2 \text{ black} + 4 \text{ striped} = 2(a + 3) + 4(3a + 1)$$

$$= 2a + 6 + 12a + 4$$

$$= 14a + 10$$

$$4 \text{ white} + 2 \text{ striped} = 4(2a + 2) + 2(3a + 1)$$

$$= 8a + 8 + 6a + 2$$

$$= 14a + 10$$

a Show that

- the total length of 2 black rods and 2 striped rods is the same as the total length of 4 white rods
- the total length of 3 black rods and 3 striped rods is the same as the total length of 6 white rods
- the total length of 5 black rods and 5 striped rods is the same as the total length of 10 white rods

b What do your answers to part **a** tell you about the connection between the number of black and striped rods and the number of white rods?

c Show that

- the total length of 4 black rods and 2 white rods is the same as the total length of 8 grey rods
- the total length of 6 black rods and 3 white rods is the same as the total length of 12 grey rods
- the total length of 8 black rods and 4 white rods is the same as the total length of 16 grey rods

d What do your answers to part **c** tell you about the connection between the number of black and white rods and the number of grey rods?

Cost to hire a bicycle

Number of days	Cost in \$
0	16
1	26
2	36
3	46
4	56
5	66
6	76

- Look at the charge for 0 days.

A rectangle is shown with its length labeled as $2b(b^2 - 4b - 3)$ and its width labeled as $\frac{a^2}{2} + 3a$.

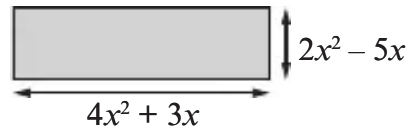
- In part **c i**, use only the $\frac{a^2}{2} + 3a$ side length.

2 Expressions and formulae

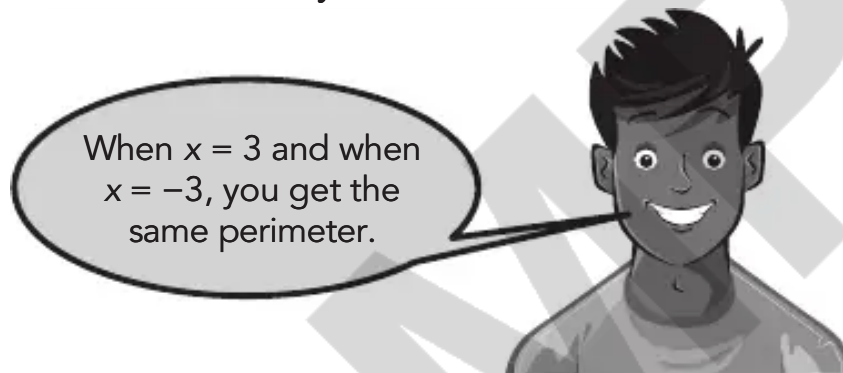
- e** When a is a positive integer, will the perimeter of the rectangle always be positive? Explain your answer.
- f** Work out the perimeter of the rectangle when
- i** $a = -1$ **ii** $a = -2$ **iii** $a = -3$
- g** Are your answers to part **f** valid measurements for the perimeter? Explain your answer.

Are there any negative values of a for which the perimeter is a valid measurement?

- ✦ **14 a** Write an expression for the perimeter of this rectangle.



- b** Show that the expression in part **a** can be simplified to $4x(3x - 1)$.
- c** Read what Arun says.



Is Arun correct? Explain your answer. Show your working.

- ✦ **15 a** A cube has a volume of 27 cm^3 . Show that the total length of all the edges of the cube is 36 cm .
- b** A cube has a volume of 64 cm^3 . Work out the total length of all the edges of the cube.
- c** A cube has a volume of $x \text{ cm}^3$. Write an expression for the total length of all the edges of the cube. Use your working for parts **a** and **b** to help you.

> 2.3 Expressions and indices

You can use the rules for indices with numbers for algebraic expressions.

Remember these rules:

i

$$x^a \times x^b = x^{a+b}$$

ii

$$x^a \div x^b = x^{a-b}$$

iii

$$(x^a)^b = x^{ab}$$

Exercise 2.3

Focus

1 Match each rectangular card with the correct oval card.

A

$x^2 \times x^4$

B

$x^3 \times x^5$

C

$x^7 \times x^2$

D

$x \times x^2$

i

x^9

ii

x^6

iii

x^3

iv

x^8

2 Match each rectangular card with the correct oval card.

A

$x^4 \div x^2$

B

$x^8 \div x^5$

C

$x^{10} \div x^4$

D

$x^9 \div x$

i

x^8

ii

x^6

iii

x^2

iv

x^3

3 Two of these statements are true and two are false.
Write 'True' or 'False' for each statement.

If the statement is false, write the correct answer.

a

$y^3 \times y^3 = y^6$

b

$y^5 \times y^4 = y^{20}$

c

$y^6 \div y = y^5$

d

$y^9 \div y^3 = y^3$

4 Copy and complete.

a

$(g^4)^2 = g^{4 \times 2}$
 $= g^{\square}$

b

$(h^6)^5 = h^{6 \times 5}$
 $= h^{\square}$

c

$(i^3)^7 = i^{3 \times 7}$
 $= i^{\square}$

d

$(j^2)^{10} = j^{2 \times 10}$
 $= j^{\square}$

5 Copy and complete. The first one has been done for you.

a

$3x^2 + 5x^2 = 8x^2$

b

$7x^3 + 9x^3 = \square x^3$

c

$6y^4 - 2y^4 = \square y^{\square}$

d

$12y^6 - y^6 = \square y^{\square}$

Tip

When you **multiply** powers of the same variable, you **add** the indices.

For expression **D**, remember $x = x^1$.

Tip

When you **divide** powers of the same variable, you **subtract** the indices.

When you simplify the power of a power, you **multiply** the indices.

Tips

When you add or subtract variables with the same power, you **do not change** the indices.

For part **d**, remember $y^6 = 1y^6$, so you need to work out $12 - 1$.

Practice

6 Simplify each expression.

a $a^3 \times a^4$

b $b^5 \times b^5$

c $c^7 \times c$

d $d^8 \div d^4$

e $e^6 \div e^2$

f $f^8 \div f$

g $(g^8)^4$

h $(y^2)^7$

i $(i^9)^8$

j $4j^2 + 9j^2$

k $6k^3 - 5k^3$

l $4l^5 + l^5 - 8l^5$

7 Simplify each expression.

a $3a^2 \times 2a^2$

b $4b^3 \times 4b^4$

c $6c^6 \times 6c^6$

d $10e^6 \times e^5$

e $16g^{12} \div 2g^4$

f $9h^9 \div 3h^3$

g $\frac{10x^{10}}{2x^2}$

h $\frac{5x^5}{x}$

8 Which is the correct answer, A, B, C or D?

a Simplify $3a^3 \times 4a^2$

A $7a^5$

B $12a^5$

C $7a^6$

D $12a^6$

b Simplify $4b^3 \times 5b$

A $20b^4$

B $20b^3$

C $9b^4$

D $9b^3$

c Simplify $\frac{15c^6}{5c^3}$

A $3c^3$

B $10c^2$

C $3c^2$

D $10c^3$

d Simplify $\frac{9d^5}{3d}$

A $3d^5$

B $6d^5$

C $6d^4$

D $3d^4$

9 Look at these algebra cards.

a Sort the cards into two groups.

Explain how you decided to sort the groups.

b Which card does not fit into either of the groups?

Explain why this is.

$x^6 \times 3x^3$

$9x^{12} \div x^9$

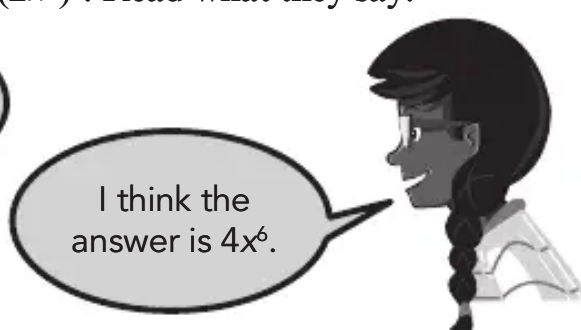
$2x \times 3x^5$

$12x^{12} \div 4x^3$

$9x^9 \div 3x^3$

$6x^6 \times x^3$

$3x^3 \times 2x^3$

10 Sofia and Zara simplify the expression $(2x^3)^2$. Read what they say.I think the answer is $4x^5$.I think the answer is $4x^6$.

a Who is correct, Sofia or Zara? Explain why.

b Simplify these expressions.

i $(3x^7)^2$

ii $(4y^9)^3$

iii $(2z^3)^5$

11 Which answer is correct, A, B, C or D?

- a Simplify $\frac{3x^9}{12x^3}$ A $4x^3$ B $4x^6$ C $\frac{1}{4}x^6$ D $\frac{1}{4}x^3$
- b Simplify $\frac{3y^6}{15y^4}$ A $\frac{1}{5}y^2$ B $\frac{1}{5}y^{1.5}$ C $5y^{1.5}$ D $5y^2$
- c Simplify $\frac{30z^{10}}{25z^5}$ A $\frac{6}{5}z^2$ B $\frac{6}{5}z^5$ C $\frac{5}{6}z^2$ D $\frac{5}{6}k^5$
- d Simplify $\frac{10w^8}{4w^8}$ A $\frac{2}{5}w$ B $\frac{2}{5}$ C $2\frac{1}{2}w$ D $2\frac{1}{2}$

Challenge

12 Fill in the missing indices in these fractions. The first one has been done for you.

- a $4^{-4} = \frac{1}{4^4}$ b $5^{-3} = \frac{1}{5^{\square}}$ c $8^{-5} = \frac{1}{8^{\square}}$
- d $x^{-4} = \frac{1}{x^{\square}}$ e $y^{-7} = \frac{1}{y^{\square}}$ f $z^{-1} = \frac{1}{z^{\square}}$

13 Simplify these expressions. Write each expression as a negative power and as a fraction.

The first one has been started for you.

- a $\frac{x^5}{x^8} = x^{5-8} = x^{-3} = \frac{1}{x^{\square}}$ b $\frac{y^3}{y^7}$ c $\frac{m^2}{m^{10}}$ d $\frac{n}{n^6}$

14 Here are six rectangular cards and seven oval cards.

The expressions on the rectangular cards have been simplified to give the expressions on the oval cards.

A $10y^4 \div 15y^8$	B $12y^3 \div 16y^7$	C $20y^4 \div 12y^{10}$	D $\frac{12y^6}{9y^{10}}$	E $\frac{7y}{21y^6}$	F $\frac{24y^4}{8y^9}$
-----------------------------	-----------------------------	--------------------------------	----------------------------------	-----------------------------	-------------------------------

i $\frac{5}{3y^6}$	ii $\frac{1}{3y^5}$	iii $\frac{3}{4y^4}$	iv $\frac{3}{y^5}$	v $\frac{2}{3y^4}$	vi $\frac{5}{2y^7}$	vii $\frac{4}{3y^4}$
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- a Match each rectangular card with the correct oval card.
- b There is one oval card left. Write an expression that simplifies to give the expression on this card.

15 Show that the expression $\frac{2n^2 \times 3n^5}{(2n^2)^3}$ simplifies to $\frac{3n}{4}$

- 16 Do the expressions $\frac{6x^2 \times 3x^6 \times 2x^9}{4x^{13}}$ and $\frac{(3x^4)^4}{3x \times x^2 \times 3x^9}$ simplify to give the same expression?
Show your working.

Tip

For Question 15, simplify the numerator, then the denominator, then combine your two expressions.

2.4 Expanding the product of two linear expressions

Exercise 2.4 Focus

Key words
brackets
expand

1 Copy and complete these multiplications, using the multiplication grid.

a 23×34

\times	20	3
30	600	90
4	80	12

Answer: $600 + 90 + 80 + 12 = \square$

b 18×42

\times	10	8
40	400	
2		

Answer: $400 + \square + \square + \square = \square$

2 Use the same method as in Question 1 to **expand** these **brackets**.
The first one has been done for you.

a $(x + 2)(x + 3)$

\times	x	+2
x	x^2	$+2x$
+3	$+3x$	$+6$

Answer: $x^2 + 2x + 3x + 6 =$
 $x^2 + 5x + 6$

b $(x + 1)(x + 4)$

\times	x	+1
x	x^2	
+4		

Answer: $x^2 + \square + \square + \square =$
 $x^2 + \square + \square$

c $(x + 5)(x + 6)$

\times	x	+5
x	x^2	
+6		

Answer: $x^2 + \square + \square + \square =$
 $x^2 + \square + \square$

d $(x + 3)(x + 9)$

\times	x	+3
x		
+9		

Answer: $x^2 + \square + \square + \square =$
 $x^2 + \square + \square$

- 3** Use the same method as in Question 2 to expand these brackets.
The first one has been done for you.

a $(x + 5)(x - 3)$

\times	x	$+5$
x	x^2	$+5x$
-3	$-3x$	-15

Answer: $x^2 + 5x - 3x - 15 =$
 $x^2 + 2x - 15$

b $(x + 6)(x - 2)$

\times	x	$+6$
x	x^2	
-2		

Answer: $x^2 + \square - \square - \square$
 $= x^2 + \square - \square$

Tip

Take care with the minus signs.

c $(x - 7)(x + 4)$

\times	x	-7
x	x^2	
$+4$		

Answer: $x^2 - \square + \square - \square$
 $= x^2 - \square - \square$

d $(x - 8)(x + 2)$

\times	x	-8
x		
$+2$		

Answer: $x^2 - \square + \square - \square$
 $= x^2 - \square - \square$

- 4** Use the same method as in Question 2 to expand these brackets.
The first one has been started for you.

a $(x - 1)(x - 3)$

\times	x	-1
x	x^2	$-1x$
-3	$-3x$	$+3$

Answer: $x^2 - \square - \square + 3$
 $= x^2 - \square + \square$

b $(x - 4)(x - 8)$

\times	x	-4
x		
-8		

Answer: $x^2 - \square - \square + \square$
 $= x^2 - \square + \square$

Tip

Take care with the minus signs.

- 5** In questions 2, 3 and 4, you used a multiplication grid to expand two brackets.

Do you prefer to use the arc method shown here?

$(x + 8)(x - 4) = x^2 - 4x + 8x - 32$
 $= x^2 + 4x - 32$

Or do you prefer the multiplication grid method shown here?

\times	x	$+8$
x	x^2	$+8x$
-4	$-4x$	-32

$= x^2 + 8x - 4x - 32 = x^2 + 4x - 32$

Or do you prefer a different method? Explain your answer.

Practice

6 Expand and simplify each expression.

a $(x + 5)(x + 2)$

b $(x + 4)(x - 2)$

c $(x - 6)(x + 3)$

d $(x - 3)(x - 3)$

e $(x + 5)(x + 10)$

f $(x - 5)(x - 8)$

g $(x - 5)(x + 10)$

h $(x + 5)(x - 8)$

7 Which answer is correct, A, B or C?

a $(w + 7)(w + 8) =$ A $w^2 + 15w + 15$

B $w^2 + 15w + 56$

C $w^2 + w + 56$

b $(x + 5)(x - 3) =$ A $x^2 + 2x - 15$

B $x^2 - 8x - 2$

C $x^2 + 8x - 15$

c $(y - 6)(y + 4) =$ A $y^2 - 10y - 2$

B $y^2 - 2y - 2$

C $y^2 - 2y - 24$

d $(z - 3)(z - 5) =$ A $z^2 - 2z + 8$

B $z^2 + 8z - 15$

C $z^2 - 8z + 15$

8 This is part of Rohan's homework.
He has made a mistake in every question.

Question

Expand and simplify each expression.

1 $(x + 4)(x + 3)$

2 $(x + 5)(x - 9)$

3 $(x - 3)(x - 2)$

Answer

1 $x^2 + 4x + 3x + 7 = x^2 + 7x + 7$

2 $x^2 + 5x - 9x - 45 = x^2 + 4x - 45$

3 $x^2 - 2x - 3x - 6 = x^2 - 5x - 6$

Explain the mistakes Rohan has made and write the correct solutions.

9 a Expand and simplify each expression.

i $(a + 2)^2$

ii $(a - 2)^2$

iii $(b + 4)^2$

iv $(b - 4)^2$

v $(c + 1)^2$

vi $(c - 1)^2$

b Compare your answers to i and ii, iii and iv, v and vi.

What is the same and what is different about your answers to each pair of expansions?

c Use your answer to part b to copy and complete this general expression:

$(x + y)^2 = x^2 + 2xy + y^2$ so $(x - y)^2 = \dots\dots\dots$

- 10 a Expand and simplify each expression.
- $(a - 1)(a + 1)$
 - $(a - 4)(a + 4)$
 - $(a + 9)(a - 9)$
- b What do you notice about your answers in part a?
- c Write the simplified expansion of $(a - 8)(a + 8)$.
- d Write the simplified expansion of $(a + b)(a - b)$.

Challenge

- 11 Show that $(x + 4)(x - 3) + x(5 - x) = 6(x - 2)$
- 12 a Expand and simplify i $(x + 6)^2$ ii $(x + 5)(x + 7)$
 b What do you notice about your answers to part a, i and ii?
- 13 a Expand and simplify i $(x + 7)^2$ ii $(x + 6)(x + 8)$
 b What do you notice about your answers to part a, i and ii?
- 14 Try some examples of your own, similar to questions 12 and 13.
 What general rules do you notice?
- 15 a Show that $(2x + 1)(3x + 2) = 6x^2 + 7x + 2$
 b Expand and simplify
 i $(3x + 1)(4x + 5)$ ii $(4y + 3)(2y - 5)$

Tip

In Question 11, start by working with the left-hand side of the equation.

> 2.5 Simplifying algebraic fractions

Exercise 2.5

Throughout this exercise, give each answer as a fraction in its simplest form.

Key words

algebraic fraction

Focus

- 1 Copy and complete these calculations.

a $\frac{1}{3} + \frac{1}{3} = \frac{\boxed{}}{3}$

b $\frac{1}{5} + \frac{2}{5} = \frac{\boxed{}}{\boxed{}}$

c $\frac{2}{7} + \frac{3}{7} = \frac{\boxed{}}{\boxed{}}$

d $\frac{1}{8} + \frac{3}{8} = \frac{4}{8} = \frac{\boxed{}}{\boxed{}}$

e $\frac{1}{9} + \frac{2}{9} = \frac{\boxed{}}{\boxed{}} = \frac{\boxed{}}{\boxed{}}$

f $\frac{3}{10} + \frac{3}{10} = \frac{\boxed{}}{\boxed{}} = \frac{\boxed{}}{\boxed{}}$

2 Copy and complete these calculations.

Use your answers to Question 1. The first one has been done for you.

a $\frac{x}{3} + \frac{x}{3} = \frac{2x}{3}$

b $\frac{x}{5} + \frac{2x}{5} = \frac{\boxed{}}{\boxed{}}$

c $\frac{2y}{7} + \frac{3y}{7} = \frac{\boxed{}}{\boxed{}}$

d $\frac{y}{8} + \frac{3y}{8} = \frac{4y}{8} = \frac{\boxed{}}{\boxed{}}$

e $\frac{m}{9} + \frac{2m}{9} = \frac{\boxed{}}{\boxed{}} = \frac{\boxed{}}{\boxed{}}$

f $\frac{3n}{10} + \frac{3n}{10} = \frac{\boxed{}}{\boxed{}} = \frac{\boxed{}}{\boxed{}}$

3 Work out the answers to these calculations by finding a common denominator.

a $\frac{1}{4} + \frac{3}{8} = \frac{2}{8} + \frac{3}{8} = \frac{\boxed{}}{\boxed{}}$

b $\frac{1}{3} + \frac{2}{9} = \frac{\boxed{}}{\boxed{}} + \frac{\boxed{}}{\boxed{}} = \frac{\boxed{}}{\boxed{}}$

c $\frac{2}{3} - \frac{1}{6} = \frac{\boxed{}}{\boxed{}} - \frac{\boxed{}}{\boxed{}} = \frac{\boxed{}}{\boxed{}} = \frac{\boxed{}}{\boxed{}}$

d $\frac{11}{12} - \frac{1}{6} = \frac{\boxed{}}{\boxed{}} - \frac{\boxed{}}{\boxed{}} = \frac{\boxed{}}{\boxed{}} = \frac{\boxed{}}{\boxed{}}$

Tip

In part **b**, change $\frac{1}{3}$ into $\frac{\boxed{}}{9}$.

4 Write the answers to these calculations. Use your answers to Question 3.

a $\frac{x}{4} + \frac{3x}{8} = \frac{\boxed{}}{\boxed{}}$

b $\frac{y}{3} + \frac{2y}{9} = \frac{\boxed{}}{\boxed{}}$

c $\frac{2p}{3} - \frac{p}{6} = \frac{\boxed{}}{\boxed{}}$

d $\frac{11b}{12} - \frac{b}{6} = \frac{\boxed{}}{\boxed{}}$

Practice

5 Simplify each expression.

a $\frac{x}{4} + \frac{x}{4}$

b $\frac{3x}{5} + \frac{x}{5}$

c $\frac{x}{6} + \frac{x}{6}$

d $\frac{5x}{7} + \frac{x}{7}$

e $\frac{7x}{8} + \frac{x}{8}$

f $\frac{y}{3} - \frac{y}{6}$

g $\frac{2y}{3} - \frac{4y}{9}$

h $\frac{2y}{3} - \frac{11y}{18}$

i $\frac{5y}{8} - \frac{5y}{16}$

j $\frac{3y}{4} - \frac{y}{24}$

6 Here are some algebraic fraction cards.

A $\frac{9x}{10} - \frac{13x}{20}$

B $\frac{x}{6} + \frac{x}{3}$

C $\frac{2x}{7} + \frac{3x}{14}$

D $\frac{11x}{18} - \frac{13x}{36}$

E $\frac{11x}{15} - \frac{2x}{5}$

F $\frac{x}{12} + \frac{x}{6}$

- Sort the cards into two groups. Explain your reasons for sorting the cards.
- Which card does not fit into either of the groups? Explain why.

7 Simplify each expression.

a $\frac{x}{2} + \frac{y}{2}$

b $\frac{x}{3} + \frac{y}{6}$

c $\frac{3x}{4} + \frac{y}{12}$

d $\frac{5x}{6} - \frac{y}{18}$

e $\frac{7x}{12} - \frac{2y}{3}$

f $\frac{3a}{4} + \frac{b}{7}$

g $\frac{5a}{9} + \frac{5b}{6}$

h $\frac{a}{7} - \frac{b}{5}$

i $\frac{5a}{8} - \frac{b}{12}$

8 This is part of Seren's homework.

Question

Simplify $\frac{8x+2}{2}$

Answer

$$\frac{8x+2}{2} = \frac{8x+2}{2} = 8x$$

- a Substitute $x = 4$ into $\frac{8x+2}{2}$ and work out the answer.
- b Substitute $x = 4$ into $8x$ and work out the answer.
- c Use your answers to parts a and b to show that Seren's answer is incorrect. Explain the mistake she has made.
- d Copy and complete the correct solution for Seren.

$$\frac{8x+2}{2} = \frac{2(\square x+1)}{2} = \frac{2^1(\square x+1)}{2^1} = \square x+1$$

9 Simplify these expressions. Make sure you factorise the numerator before you cancel with the denominator.

a $\frac{10x+5}{5}$

b $\frac{15x+3}{3}$

c $\frac{12x-16}{4}$

d $\frac{18x-24}{6}$

Challenge

10 Evan thinks the expression $\frac{7x-14}{7} + \frac{8x+6}{2}$ simplifies to $5x+1$.

Is Evan correct? Show your working.

11 a Show that the fraction $\frac{8x+24}{4}$ can be simplified to $2x+6$ or $2(x+3)$.

b Simplify these fractions. Write two expressions for each answer; one with brackets and one without brackets.

i $\frac{6x+12}{3}$

ii $\frac{15x+45}{5}$

iii $\frac{24x-36}{4}$

iv $\frac{32-48x}{8}$

12 This is part of Brad's classwork.

Question

Simplify $\frac{20x + 4}{8}$

Answer

$$\frac{20x + 4}{8} = \frac{4(5x + 1)}{8} = \frac{\cancel{4}^1(5x + 1)}{\cancel{8}^2} = \frac{5x + 1}{2}$$

Use Brad's method to simplify these fractions.

a $\frac{6x + 9}{6}$

b $\frac{20x + 30}{50}$

c $\frac{4x - 6}{8}$

d $\frac{30 - 42x}{12}$

13 You already know that you add and subtract fractions by using a common denominator.

For example: $\frac{4}{5} + \frac{2}{3} = \frac{4 \times 3 + 2 \times 5}{5 \times 3} = \frac{12 + 10}{15} = \frac{22}{15}$

You can use the same method with algebraic fractions.

For example, $\frac{1}{a} + \frac{1}{b} = \frac{1 \times b + 1 \times a}{ab} = \frac{b + a}{ab}$

Use the method shown to add and subtract these fractions.

a $\frac{1}{x} + \frac{1}{y}$

b $\frac{1}{c} + \frac{1}{d}$

c $\frac{1}{x} - \frac{1}{y}$

d $\frac{2}{a} + \frac{1}{b}$

e $\frac{5}{m} - \frac{2}{n}$

f $\frac{3}{g} - \frac{4}{h}$

Tip

Remember to take out the highest common factor when you factorise the numerator of each fraction.

> 2.6 Deriving and using formulae

Exercise 2.6

Focus

- 1 You already know a lot of mathematical formulae.
Match each rectangular card with the correct oval card.

A Area of a triangle

B Volume of a cuboid

C Area of a parallelogram

D Circumference of a circle

E Area of a trapezium

F Area of a circle

i $A = \pi r^2$

ii $A = bh$

iii $C = \pi d$

iv $V = lbh$

v $A = \frac{1}{2}bh$

vi $A = \frac{1}{2}(a + b)h$

Key words

changing the
subject
subject of a
formula

- 2 a Work out the number of hours in
i 1 day ii 2 days
iii 3 days iv d days.
b The formula to work out the number of hours (H) in d days
is $H = 24d$.

Copy and complete the working to find the number of hours
in 10 days.

$$H = 24d = 24 \times d = 24 \times 10 = \square$$

Tip

Substitute $d = 10$
into the formula.

- 3 a Work out the number of days in
i 1 week ii 2 weeks
iii 3 weeks iv w weeks.
b Copy and complete the formula to work out the number of
days (D) in w weeks: $D = \dots\dots$

Use your formula to find the number of days in 8 weeks.

- 4 a Work out the total number of days in
i 1 week and 2 days ii 3 weeks and 4 days
iii w weeks and d days.

- b** The formula to work out the total number of days (T) in w weeks and d days is $T = 7w + d$.

Use the formula to work out the total number of days in

i 2 weeks and 5 days

ii 6 weeks and 3 days.

- 5** Copy and complete the workings to make b the **subject** of each formula.

The first one has been done for you.

- a** $A = bh$ $A = b \times h$ swap sides: $b \times h = A$ reverse the \times : $b = \frac{A}{h}$
- b** $F = bg$ $F = b \times g$ swap sides: $b \times \square = \square$ reverse the \times : $b = \frac{\square}{\square}$
- c** $T = mb$ $T = m \times b$ swap sides: $\square \times \square = \square$ reverse the \times : $b = \frac{\square}{\square}$
- d** $X = b + rt$ swap sides: $b + rt = \square$ reverse the $+$: $b = X - \square$
- e** $M = b - kn$ swap sides: $b - \square = \square$ reverse the $-$: $b = \square + \square$

Practice

- 6** **a** Use the formula $D = ST$ to work out the value of D when
- i** $S = 50$ and $T = 3$ **ii** $S = 120$ and $T = 1.5$
- b** Rearrange the formula $D = ST$ to make S the subject.
Work out the value of S when $D = 100$ and $T = 5$.
- c** Rearrange the formula $D = ST$ to make T the subject.
Work out the value of T when $D = 22$ and $S = 4$.
- 7** Stanley is d years old. Polly is 3 years **older** than Stanley.
Max is 2 years **younger** than Stanley.
- a** Write an expression for Polly's age and Max's age in terms of d .
- b** Write a formula for the total age, T , of Stanley, Polly and Max.
- c** Use your formula in part **b** to work out the value of T when $d = 8$.
- d** Rearrange your formula in part **c** to make d the subject.
- e** Use your formula in part **d** to work out the value of d when $T = 34$.
- 8** Use the formula $F = I + ae$ to work out the value of
- a** F when $I = 5$, $a = 10$ and $e = 2$
- b** F when $I = 0$, $a = 9$ and $e = 6$
- c** I when $F = 100$, $a = 4$ and $e = 15$
- d** e when $F = 50$, $I = 10$ and $a = 8$
- e** a when $F = 48$, $I = 34$ and $e = 2$.

Tip

In parts **c**, **d** and **e**, start by **changing the subject** of the formula.

- 9 Kimma buys and sells furniture. She uses the formula in the box to work out the percentage profit she makes.

Work out the percentage profit Kimma makes on each piece of furniture.

- a cost price = \$28, selling price = \$42
b cost price = \$150, selling price = \$162

$$\text{percentage profit} = \frac{\text{selling price} - \text{cost price}}{\text{cost price}} \times 100$$

- 10 In many countries, the distance of a horse race is measured in furlongs (F) and yards (Y).

A formula to convert furlongs and yards into metres (m) is shown in the box.

$$m = \frac{220F + Y}{1.09} \text{ where: } \begin{array}{l} m \text{ is the number of metres} \\ F \text{ is the number of furlongs} \\ Y \text{ is the number of yards} \end{array}$$

Work out the distance, in metres, of each horse race.
Give each answer correct to the nearest metre.

- a 2 furlongs and 50 yards b 6 furlongs and 100 yards
c 5 furlongs and 75 yards d 8 furlongs

- 11 Make x the subject of each formula. Write if A, B or C is the correct answer.

- a $y = 5x + k$ A $x = \frac{y-k}{5}$ B $x = \frac{y+k}{5}$ C $x = \frac{y}{5} - k$
b $y = \frac{x}{3} - 2ab$ A $x = 3y + 2ab$ B $x = 3(y + 2ab)$ C $x = 3y - 2ab$
c $y = \frac{g+x}{k}$ A $x = ky - g$ B $x = k(y - g)$ C $x = ky + g$
d $y = \frac{3x}{2} - 5p$ A $x = \frac{2(y-5p)}{3}$ B $x = \frac{2y}{3} + 5p$ C $x = \frac{2(y+5p)}{3}$

- 12 Make n the subject of each formula.

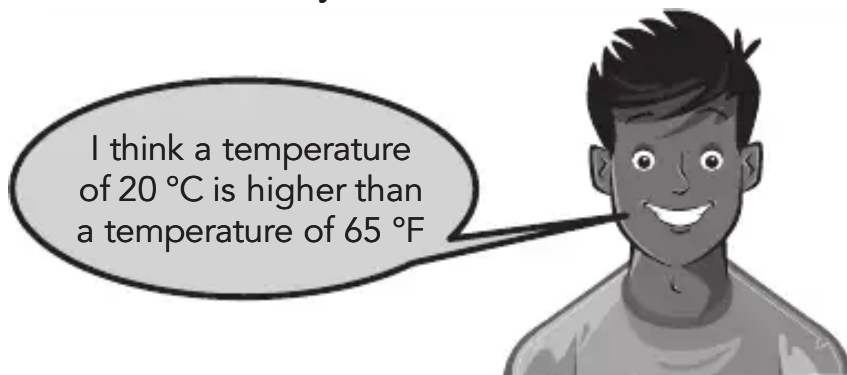
- a $p = 3n - 8$ b $q = \frac{n}{7} + k$ c $p = \frac{r+n}{2w}$ d $h = \frac{5n-2}{r^2}$

Challenge

- 13 Arun knows this relationship between temperatures in degrees Fahrenheit ($^{\circ}\text{F}$) and temperatures in degrees Celsius ($^{\circ}\text{C}$).

$$F = 1.8C + 32 \text{ where: } \begin{array}{l} F \text{ is the temperature in degrees Fahrenheit } (^{\circ}\text{F}) \\ C \text{ is the temperature in degrees Celsius } (^{\circ}\text{C}). \end{array}$$

Read what Arun says.



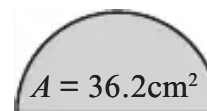
Is Arun correct? Show how you worked out your answer.

- 14 Here are two formulae that are used in science:

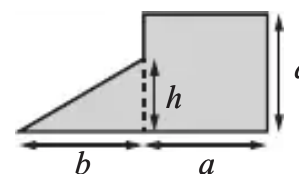
$$F = ma \quad a = \frac{v - u}{t}$$

Work out the value of F when $v = 32$, $u = 12$, $t = 5$ and $m = 30$.
Explain how you worked out your answer. Show your working.

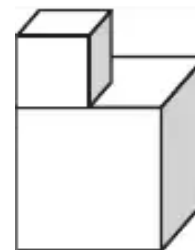
- 15 The formula for the area of a semicircle is $A = \frac{1}{2}\pi r^2$
- a Make r the subject of the formula.
 - b Work out the radius of a semicircle with an area of 36.2 cm^2 .
Write your answer correct to 2 significant figures (2 s.f.).



- 16 The diagram shows a shape made from a square and a triangle.
- a Write a formula for the area (A) of the shape.
 - b Work out A when $a = 7$, $b = 6$ and $h = 4$.
 - c Make a the subject of the formula.
 - d Work out a when $A = 174$, $b = 10$ and $h = 6$.



- 17 Ria makes this shape out of two cubes.
- The side length of the smaller cube is $x \text{ cm}$.
- The side length of the larger cube is twice the side length of the smaller cube.
- a Write an expression for the side length of the larger cube in terms of x .
 - b Write a formula for the total volume (V) of the shape in terms of x .
Write your formula in its simplest form.
 - c Make x the subject of your formula.
 - d The total volume of Ria's shape is 576 cm^3 .
Show that the surface area of the larger cube is 384 cm^2 .
Explain how you worked out your answer.



percentages and
rounding> 3.1 Multiplying and dividing by
powers of 10

Exercise 3.1

Focus

- 1 Match each rectangular card with the correct oval card.
The first one has been done for you: A and ii.

A $\times 10^0$	B $\times 10^1$	C $\times 10^2$	D $\times 10^3$	E $\times 10^4$	F $\times 10^5$
i $\times 1000$	ii $\times 1$	iii $\times 10000$			
iv $\times 100$	v $\times 100\,000$	vi $\times 10$			

- 2 Copy and complete the workings for each of these multiplications.
When you multiply, use this method of moving the decimal point:

$$5.8 \times 10^2 = 5.8 \times 100 = 580$$

- a** $3.4 \times 10^2 = 3.4 \times \square = \square$
b $4.8 \times 10^3 = 4.8 \times \square = \square$
c $12.5 \times 10^1 = 12.5 \times \square = \square$
d $5 \times 10^5 = 5 \times \square = \square$
e $14 \times 10^3 = 14 \times \square = \square$

Tips

Move the decimal point two places to the right as 100 has two zeros. 5.8.0

After you move the decimal point, remember to fill in any spaces in the answers with zeros.

For part d, 5 = 5.0

3 Match each rectangular card with the correct oval card.

The first one has been done for you: A and ii.

A $\times 10^{-1}$

B $\times 10^{-2}$

C $\times 10^{-3}$

D $\times 10^{-4}$

E $\times 10^{-5}$

i $\div 10\,000$

ii $\div 10$

iii $\div 100\,000$

iv $\div 1000$

v $\div 100$

4 Copy and complete the workings for each of these divisions.

When you divide, use this method of moving the decimal point:

$$5.8 \times 10^{-2} = 5.8 \div 100 = 0.058$$

a $3.4 \times 10^{-2} = 3.4 \div \boxed{} = \boxed{}$

b $8 \times 10^{-3} = 8 \div \boxed{} = \boxed{}$

c $15 \times 10^{-4} = 15 \div \boxed{} = \boxed{}$

d $12 \times 10^{-1} = 12 \div \boxed{} = \boxed{}$

Tips

Move the decimal point two places to the left as 100 has two zeros.

\curvearrowright
 0.058

After you move the decimal point, remember to fill in any spaces in the answer with zeros.

Practice

5 Work out

a 28×10^2

b 2.8×10^4

c 28×10

d 2.88×10^3

e 2.8×10^5

f 0.02×10^1

g 28×10^0

h 2×10^{-1}

i 2.8×10^{-2}

j 2800×10^{-4}

k 28×10^{-3}

l 288×10^{-1}

6 Work out

a $34 \div 10$

b $340 \div 10^2$

c $34 \div 10^3$

d $340 \div 10^4$

e $0.34 \div 10^1$

f $3400 \div 10^5$

g $34 \div 10^0$

h $0.34 \div 10^{-1}$

i $34 \div 10^{-2}$

j $3.04 \div 10^{-4}$

k $0.03 \div 10^{-3}$

l $0.034 \div 10^{-4}$

7 Copy this table, which is a secret coded message.

—	—	—	—	—	—	—	—	—	—	—	:	—	A	—	—	!
1.2	5	0.12	0.05	2000	0.2	5	0.5	12	0.05	50		0.05	500	0.2	0.02	

Work out the answers to the calculations in the code box.

Find the answer in your secret code table.

Write the letter from the code box above the number in your table.

For example, the first calculation is $500 \div 10^0$. $500 \div 10^0 = 500$, so write A above 500 in the table as shown.

What is the secret coded message?

$$500 \div 10^0 = A$$

$$50 \times 10^{-3} = E$$

$$0.05 \div 10^{-1} = F$$

$$0.5 \times 10^2 = N$$

$$50 \times 10^{-1} = O$$

$$12 \div 10^1 = P$$

$$0.2 \div 10^{-4} = R$$

$$200 \times 10^{-3} = S$$

$$1200 \times 10^{-2} = T$$

$$0.12 \times 10^0 = W$$

$$200 \div 10^4 = Y$$



8

a Work out

i 5×10^3

ii 5×10^2

iii 5×10^1

iv 5×10^0

v 5×10^{-1}

vi 5×10^{-2}

b When you multiply a number by 10^{-4} , is the answer larger or smaller than when you multiply the number by 10^{-5} ? Look at your answers to part a to help you decide.



9

a Work out

i $99 \div 10^3$

ii $99 \div 10^2$

iii $99 \div 10^1$

iv $99 \div 10^0$

v $99 \div 10^{-1}$

vi $99 \div 10^{-2}$

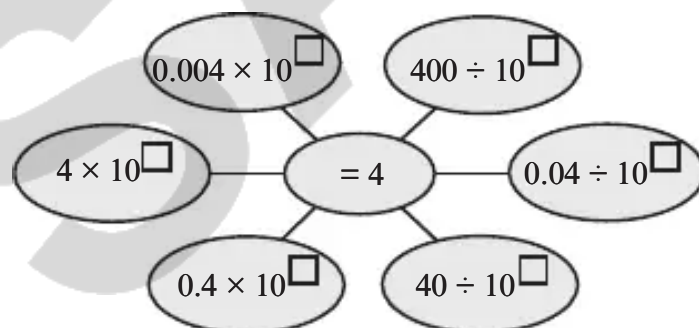
b If you divide a number by 10^{-4} , is the answer larger or smaller than when you divide the number by 10^{-5} ? Look at your answers to part a to help you decide.

Challenge

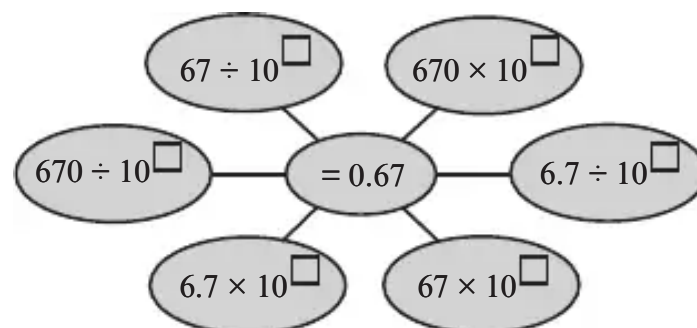
10 Work out the missing power in each question in these spider diagrams.

In each part, all the questions in the outer shapes should give the answer in the centre shape.

a



b



11 a Sort these cards into groups that give the same value.

A 450×10^{-1}	B 0.00045×10^4	C 0.45×10^0
D 0.45×10^2	E 4500×10^{-3}	F 4.5×10^{-2}
G $0.000\,0045 \times 10^5$	H 45×10^0	I 45×10^{-2}
	J 0.45×10^1	

b There is one card spare. Write two other cards that give the same value as this card.

12 Look at the numbers. Put a tick (✓) for the numbers that are written in standard form.

Put a cross (✗) for the numbers that are not written in standard form.

- a 4.5×10^3 b 1.7×10^9 c 32×10^5
d 125×10^{-2} e 2.99×10^{-8} f 0.3×10^{-7}

13 These numbers are written in standard form. Write each number as a normal number.

- a 2.7×10^2 b 4.8×10^{-3} c 1.25×10^5

14 Write whether A, B or C is the correct standard form number for each measurement.

a The mass of the Hubble Space Telescope is approximately 11 000 kg. This is the same as

- A** 1.1×10^3 kg **B** 1.1×10^4 kg **C** 1.1×10^5 kg

b The distance from the Moon to Earth is approximately 384 000 km. This is the same as

- A** 3.84×10^5 km **B** 3.84×10^4 km **C** 3.84×10^3 km

c The distance from the Earth to the Sun is approximately 150 000 000 km. This is the same as

- A** 1.5×10^7 km **B** 1.5×10^9 km **C** 1.5×10^8 km

d The length of a plant cell is approximately 0.000 05 m. This is the same as

- A** 5×10^{-6} m **B** 5×10^{-5} m **C** 5×10^{-4} m

Tip

You studied standard form in Unit 1.

> 3.2 Multiplying and dividing decimals

Exercise 3.2

Focus

- 1 Here is an example of how you can work out 8×0.3

$$8 \times 3 = 24$$

$$8 \times 0.3 = 2.4$$

This method works because you change 0.3 to 3 by multiplying by 10: $0.3 \times 10 = 3$

Then you divide the answer of 24 by 10:

$$24 \div 10 = 2.4$$

Copy and complete these multiplications.

- | | | | | |
|----------|-------------------|--------------------------|----|-----------------------------|
| a | 4×0.3 | $4 \times 3 = 12$ | so | $4 \times 0.3 = \square$ |
| | 7×0.4 | $7 \times 4 = \square$ | so | $7 \times 0.4 = \square$ |
| b | 9×-0.1 | $9 \times -1 = \square$ | so | $9 \times -0.1 = \square$ |
| c | -15×0.2 | $-15 \times 2 = \square$ | so | $-15 \times 0.2 = \square$ |
| d | 8×0.02 | $8 \times 2 = 16$ | so | $8 \times 0.02 = \square$ |
| e | -5×-0.04 | $-5 \times -4 = \square$ | so | $-5 \times -0.04 = \square$ |
| f | 11×0.07 | $11 \times 7 = \square$ | so | $11 \times 0.07 = \square$ |

Tip

Remember:

$$+ \times + = +$$

$$+ \times - = -$$

$$- \times + = -$$

$$- \times - = +$$

- 2 Here is an example of how you can work out $12 \div 0.3$

$$12 \times 10 = 120$$

$$0.3 \times 10 = 3$$

$$120 \div 3 = 40$$

This method works because when you are dividing two numbers, if you multiply both numbers by 10, 100 or any other number, the answer to the division will remain the same. In this example you multiply both numbers by 10 so that 0.3 becomes a whole number instead of a decimal.



Copy and complete these divisions.

a	$6 \div 0.3$	$6 \times 10 = 60$	$0.3 \times 10 = 3$	$60 \div 3 = \square$
b	$8 \div 0.2$	$8 \times 10 = 80$	$0.2 \times 10 = \square$	$80 \div \square = \square$
c	$-9 \div 0.1$	$-9 \times 10 = \square$	$0.1 \times 10 = \square$	$\square \div \square = \square$
d	$12 \div 0.4$	$12 \times 10 = \square$	$0.4 \times 10 = \square$	$\square \div \square = \square$
e	$6 \div -0.02$	$6 \times 100 = 600$	$-0.02 \times 100 = -2$	$600 \div -2 = \square$
f	$8 \div 0.04$	$8 \times 100 = \square$	$0.04 \times 100 = \square$	$\square \div \square = \square$
g	$-16 \div -0.08$	$-16 \times 100 = \square$	$-0.08 \times 100 = \square$	$\square \div \square = \square$

Practice

3 Work out mentally

a	4×0.3	b	13×0.2	c	4×0.9	d	0.9×-9
e	0.3×11	f	8×-0.03	g	14×0.02	h	-15×-0.03
i	0.02×70	j	0.05×-111				

4 Sort these cards into groups that have the same answer.

A	0.006×4	B	40×0.06	C	0.004×6	D	4×0.06
E	0.04×0.6	F	0.6×4	G	0.4×0.6	H	0.4×6
I	0.4×0.06	J	0.006×40	K	600×0.004	L	6×0.04

5 Work out mentally

a	$6 \div 0.3$	b	$8 \div 0.2$	c	$18 \div 0.6$	d	$-28 \div 0.7$
e	$20 \div 0.1$	f	$5 \div -0.02$	g	$9 \div 0.03$	h	$-30 \div -0.01$
i	$36 \div 0.18$	j	$48 \div -0.12$				

6 Write the correct answer to each calculation, A, B, C or D.

a	$0.9 \div 0.03 = \square$	A	300	B	30	C	3	D	0.3
b	$3.5 \div 0.5 = \square$	A	0.7	B	7	C	70	D	700
c	$0.08 \div 0.004 = \square$	A	2000	B	200	C	20	D	2
d	$0.25 \div 0.05 = \square$	A	0.5	B	5	C	50	D	500

7 Work out mentally

a	0.6×0.2	b	4.5×0.3	c	0.18×0.4	d	0.06×2.5
e	0.11×0.5	f	$0.6 \div 0.02$	g	$2.7 \div 0.3$	h	$0.45 \div 0.09$
i	$0.28 \div 0.04$	j	$3.6 \div 0.09$				

a $11.23 \times 1.5 > 11.23$

b $5.92 \div 0.75 > 5.92$

c $8.6 \times 0.99 > 8.6$

d $0.49 \div 1.25 < 0.49$

Tip

Do not work out the answers to the multiplications and divisions.

- 9 This is part of Hassan's homework.

Question

Work out $\frac{2.5 \times 0.2}{5 \times 0.1}$

Answer

Numerator: $2.5 \times 0.2 = 5.0$ Denominator: $5 \times 0.1 = 50$

$$5 \div 50 = 0.1$$

Is Hassan correct? Explain your answer.

- 10 Work out the answer to each question.

a $\frac{16 \times 0.2}{0.02 \times 8}$

b $\frac{1500 \times 0.03}{7.5 \times 0.2}$

c $\frac{0.25 \times 100}{0.002 \times 25}$

d $\frac{80 \times 0.2 \times 0.2}{40 \times 0.4}$

- 11 a Work out mentally

i 11×0.1

ii 11×0.2

iii 11×0.3

iv 11×0.4

v 11×0.5

vi 11×0.6

- b Use your answers to part a to answer these questions.

i When you multiply a number by 0.9, do you expect the answer to be larger or smaller than your answer when you multiply the same number by 0.3?

ii When you multiply a number by a decimal between 0 and 1, do you expect the answer to be larger or smaller than the number you started with?

- c Work out mentally

i $8 \div 0.1$

ii $8 \div 0.2$

iii $8 \div 0.4$

iv $8 \div 0.5$

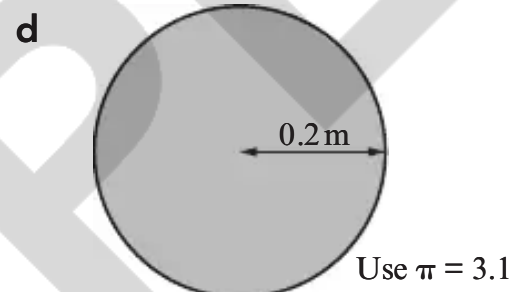
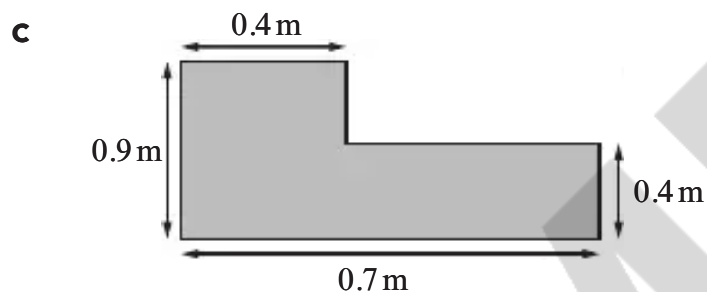
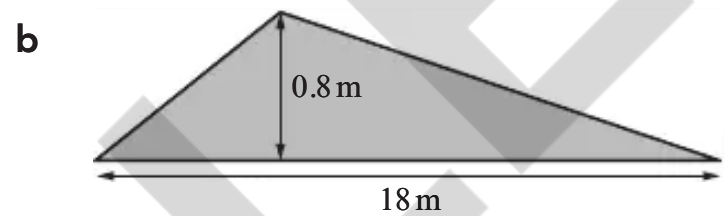
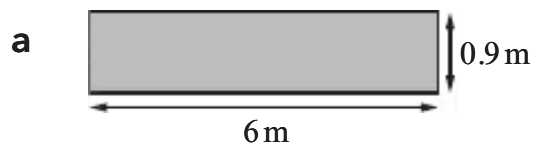
v $8 \div 0.8$

- d Use your answers to part c to answer these questions.

i When you divide a number by 0.6, do you expect your answer to be larger or smaller than when you divide the same number by 0.7?

ii When you divide a number by a decimal between 0 and 1, do you expect the answer to be larger or smaller than the number you started with?

- 12** Use the fact that $45 \times 352 = 15\,840$ to write the answers to these calculations.
- a** 45×3.52 **b** 4.5×35.2 **c** 0.45×0.0352
d $15\,840 \div 45$ **e** $15.840 \div 45$ **f** $1.5840 \div 0.45$
- 13** Estimate and work out the answers to these calculations.
- 14** **a** 6.21×43.7 **b** $207.9 \div 0.42$ **c** 75×4.8



- 15** A rectangle has an area of 0.32 m^2 . The height of the rectangle is 0.08 m .

What is the length of the rectangle?

- 16** A circle has circumference 2.17 m . What is the radius of the circle?

- 17** Write 'True' or 'False' for each statement. If the answer is false, work out the correct answer.

- a** $0.4^2 = 0.16$ **b** $1.2^2 = 1.44$ **c** $0.05^2 = 0.025$
d $\sqrt{0.09} = 0.03$ **e** $\sqrt{1.69} = 1.3$ **f** $\sqrt{0.4}^2 = 0.4$
 ()

Tip

For Question **16**,
use $\pi = 3.1$

percentages

Exercise 3.3

Focus

Key words

compound percentage

- Copy and complete the workings for these percentage increases.
 - \$300 increased by 15% $100\% + 15\% = 115\%$ multiplier is 1.15
 $\$300 \times 1.15 = \$\boxed{}$
 - \$200 increased by 20% $100\% + 20\% = 120\%$ multiplier is $\boxed{}$
 $\$200 \times \boxed{} = \$\boxed{}$
 - \$400 increased by 32% $100\% + 32\% = 132\%$ multiplier is $\boxed{}$
 $\$400 \times \boxed{} = \$\boxed{}$
- Copy and complete the workings for these percentage decreases.
 - \$300 decreased by 15% $100\% - 15\% = 85\%$ multiplier is 0.85
 $\$300 \times 0.85 = \$\boxed{}$
 - \$200 decreased by 20% $100\% - 20\% = 80\%$ multiplier is $\boxed{}$
 $\$200 \times \boxed{} = \$\boxed{}$
 - \$400 decreased by 32% $100\% - 32\% = 68\%$ multiplier is $\boxed{}$
 $\$400 \times \boxed{} = \$\boxed{}$
- The rectangular cards show percentage increases and decreases.
 The oval cards show multipliers.
 Match each rectangular card with the correct oval card.
 The first one has been done for you: **A** and **vi**.

A increase by 10%	B increase by 40%	C decrease by 25%
D decrease by 5%	E increase by 4%	F decrease by 62%
i 0.75	ii 1.04	iii 1.4
iv 0.95	v 0.38	vi 1.1

compound percentage changes.

- a \$800 increased by 10%, then increased by 20%

$$800 \times 1.1 = 880 \quad \rightarrow \quad 880 \times 1.2 = \$ \boxed{}$$

- b \$800 decreased by 10%, then decreased by 20%

$$800 \times 0.9 = \boxed{} \quad \rightarrow \quad \boxed{} \times \boxed{} = \$ \boxed{}$$

- c \$800 increased by 25%, then decreased by 40%

$$800 \times \boxed{} = \boxed{} \quad \rightarrow \quad \boxed{} \times \boxed{} = \$ \boxed{}$$

- d \$800 increased by 5%, then decreased by 15%

$$800 \times \boxed{} = \boxed{} \quad \rightarrow \quad \boxed{} \times \boxed{} = \$ \boxed{}$$

- 5 a Work out these compound percentage changes.

- i 200 increased by 10%, then decreased by 10%

- ii 200 decreased by 10%, then increased by 10%

- b Which sign, <, > or =, is missing from this sentence?

200 increased by 10%, then decreased by 10%

☐ 200 decreased by 10%, then increased by 10%

- c Without doing any calculations, decide which sign, <, > or =, is missing from each sentence.

- i 40 decreased by 30%, then increased by 30%

☐ 40 increased by 30%, then decreased by 30%

- ii 156 increased by 2%, then decreased by 2%

☐ 156 decreased by 2%, then increased by 2%

Practice

- 6 a Raj uses this method to work out 50 increased by 20%, then increased by 10%.

$$50 \times 1.2 \times 1.1 = 66$$

Use Raj's method to work out the final value after these compound percentage increases.

- i 60 increased by 30%, then increased by 10%

- ii 200 increased by 25%, then increased by 45%

- b Mari uses this method to work out 50 increased by 20%, then increased by 10%.

then increased by 10%.

$$1.2 \times 1.1 = 1.32 \quad \rightarrow \quad 50 \times 1.32 = 66$$

Use Mari's method to work out the final value after these compound percentage increases.

- i 300 increased by 80%, then increased by 65%
- ii 40 increased by 16%, then increased by 5%

- 7 Patsi works out the percentage increase of the price of a litre of petrol over two weeks.

In the first week, the price of a litre of petrol increased by 5%.

In the second week, the price of a litre of petrol increased by 2%.

- a Use Mari's method from Question 6 to work out the multiplier for the compound percentage change.
- b At the start of the first week the price of a litre of petrol was \$1.20
What is the price of a litre of petrol at the end of the second week?

- 8 a Give your answer to the nearest cent.
Raj uses this method to work out 50 decreased by 20%, then decreased by 10%.

$$50 \times 0.8 \times 0.9 = 36$$

Use Raj's method to work out the final value after these compound percentage decreases.

- i 80 decreased by 40%, then decreased by 30%
- ii 600 decreased by 75%, then decreased by 20%
- b Mari uses this method to work out 50 decreased by 20%, then decreased by 10%

$$0.8 \times 0.9 = 0.72 \quad \rightarrow \quad 50 \times 0.72 = 36$$

Use Mari's method to work out the final value after these compound percentage decreases.

- i 200 decreased by 15%, then decreased by 25%
- ii 90 decreased by 10%, then decreased by 5%



In the second year, the value of the computer decreases by 16%.

- a Use Mari’s method from Question 8 to work out the multiplier for the compound percentage change.
- b Marcus pays \$840 for his computer. What will be the value of his computer after two years?



10 Harper invests \$4000 in a bank account. At the end of each year, the value of 5% of the money in her account is added to her account. She works out how much she will have in her account at the end of each year for five years.
Copy and complete her calculations. Write all amounts correct to the nearest cent.

End of year	Calculation	Amount
1	4000×1.05	\$4200.00
2	$4000 \times (1.05)^2$	\$4410.00
3	$4000 \times (1.05)^3$	\$ <input type="text"/>
4	$4000 \times (1.05)^{\square}$	\$ <input type="text"/>
5	$4000 \times (1.05)^{\square}$	\$ <input type="text"/>

- 11 A scooter has a value of \$1800. The value of the scooter is predicted to decrease at a steady rate of 12% per year.
- a Write a calculation to work out the value of the scooter after
 - i 1 year
 - ii 2 years
 - iii 3 years.
 - b What does the calculation $1800 \times (0.88)^7$ represent?
 - c What does the calculation $1800 \times (0.88)^{12}$ represent?
 - d Show that the value of the scooter first falls below \$1000 after 5 years.
Show how you worked out your answer.
 - e Write a calculation to work out the value of the scooter after n years.

We are working with Cambridge Assessment International Education towards endorsement of this title.

3.3 Understanding compound percentages

Challenge

12 The rectangular cards show percentage changes. The oval cards show multipliers.

A 30% increase then 25% decrease	B 23% increase then 10% decrease	C 85% decrease then 120% increase
D 15% decrease then 132% increase	E 125% increase then 76% decrease	F 62% decrease then 250% increase

i 0.33 **ii** 0.975 **iii** 1.33 **iv** 1.972 **v** 1.107

- a** Match each oval card with the correct rectangular card.
b There is one rectangular card left over. Work out the multiplier that goes with this card.

13 Copy and complete these calculations.

- a** 60% increase then % decrease \rightarrow multiplier = 0.88 \rightarrow $\$600 \times 0.88 = \$$
b 15% decrease then % increase \rightarrow multiplier = 0.952 \rightarrow $\$$ $\times 0.952 = \$761.60$
c % increase then 24% increase \rightarrow multiplier = \rightarrow $\$400 \times$ $= \$719.20$

14 An amount of money is increased by 8%, then decreased by 15%, then increased by 20%.

- a** Write the multiplier for this percentage change.
b The amount of money after the three percentage changes is \$2643.84
 Work out the original amount of money, before the three percentage changes.

15 This is part of Sheng's homework.

Question

The multiplier after two percentage changes is 1.2

Write two different options for this multiplier.

Answer

I need to find two numbers that multiply to give 1.2

$$1.6 \times 0.75 = 1.2 \rightarrow 60\% \text{ increase, then } 25\% \text{ decrease}$$

$$1.5 \times 0.8 = 1.2 \rightarrow 50\% \text{ increase, then } 20\% \text{ decrease}$$

Use Sheng's method to write two different options for each of these multipliers.

- a** 0.6 **b** 1.5

16 The number of fish in a lake is measured each year for six years.

The number of fish in the lake is found to be decreasing at a rate of

20% each year.

After 6 years, the population of fish in the lake is 131 072.

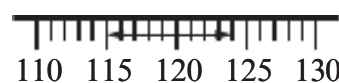
How many fish were there in the lake at the start of the first year?

> 3.4 Understanding upper and lower bounds

Exercise 3.4

Focus

- 1 A whole number is rounded to the nearest 10 and the answer is 120.



Use the number line to copy and complete these statements.

- a The whole numbers that round to 120 are 115, 116, 117, , , , , , .
- b The **lower bound** is .
- c The **upper bound** is .
- 2 A whole number is rounded to the nearest 10 and the answer is 70.



Use the number line to write

- a the whole numbers that round to 70
- b the lower bound
- c the upper bound.

Key words

lower bound
upper bound

Tip

When a number is rounded to the nearest 10, the number could be up to 5 above and 5 below the rounded number. As you know the number must be a whole number, it can only be

from 115 up to 124.

- 3 A number with one decimal place is rounded to the nearest whole number. The answer is 25.



Tip

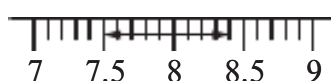
When a number

24 24.5 25 25.5 26

Use the number line to copy and complete these statements.

- a** The numbers with one decimal place that round to 25 are 24.5, 24.6, 24.7, , , , , ,
- b** The lower bound is
- c** The upper bound is

- 4** A number with one decimal place is rounded to the nearest whole number. The answer is 8.



Use the number line to write

- a** the numbers with one decimal place that round to 8
- b** the lower bound
- c** the upper bound.
- 5** A decimal number is rounded to the nearest whole number. The answer is 3.



Use the number line to write

- a** the lower bound **b** the upper bound.
- 6** A decimal number is rounded to the nearest 10 and the answer is 90.



Use the number line to write

- a** the lower bound **b** the upper bound.

Practice

- 7** A decimal number is rounded to the nearest whole number. Write an inequality to show the range of values the number can be when

- a** the answer is 7 $\rightarrow 6.5 \leq x < 7.5$ **b** the answer is 28
- c** the answer is 135 **d** the answer is 559

The first one has been done for you.

When a number is rounded to the nearest one, the number could be up to 0.5 above and 0.5 below the rounded number. As you know the number has one decimal place, it can only be from 24.5 up to 25.4

Tip

As the number can be any decimal number that rounds to 3, it can be from 2.5 up to, but not including, 3.5. You can write this as an inequality: $2.5 \leq x < 3.5$

Tip

As the number can be any decimal number that rounds to 90, it can be from 85 up to, but not including, 95. You can write this as an inequality: $85 \leq x < 95$

- 8** A decimal number is rounded to the nearest ten.

Copy and complete each inequality to show the range of values the number can be when

number can be when

- a the answer is 50 $\rightarrow 45 \leq x < \boxed{}$
- b the answer is 420 $\rightarrow \boxed{} \leq x < 425$
- c the answer is 3740 $\rightarrow \boxed{} \leq x < \boxed{}$
- d the answer is 5210 $\rightarrow \boxed{} \leq x < \boxed{}$

9 A decimal number is rounded to the nearest one hundred.

Copy and complete each inequality to show the range of values the number can be when

- a the answer is 800 $\rightarrow 750 \leq x < \boxed{}$
- b the answer is 1200 $\rightarrow \boxed{} \leq x < 1250$
- c the answer is 6700 $\rightarrow \boxed{} \leq x < \boxed{}$
- d the answer is 9100 $\rightarrow \boxed{} \leq x < \boxed{}$

10 Vihaan works out the area of this pond to be 19 m^2 , correct to the nearest metre. Write

- a the lower bound of the area
- b the upper bound of the area
- c an inequality to show the range of values the area could be.

11 Saarya works out the mean number of points her netball team scores each match to be 60 points, correct to the nearest 10 points.

- a Write
 - i the lower bound of the mean number of points
 - ii the upper bound of the mean number of points.
- b Write an inequality to show the range of values the mean number of points could be.



Challenge

12 The rectangular cards show a range of values that a rounded number can be.

The oval cards show the degree of accuracy of the rounding.

The hexagonal cards show the rounded numbers.

Match each rectangular card with the correct oval card and the correct hexagonal card.

A $195 \leq x < 205$

B $415 \leq x < 425$

C $2350 \leq x < 2450$

D $23.5 \leq x < 24.5$

E $350 \leq x < 450$

F $4199.5 \leq x < 4200.5$

i nearest 100

ii nearest 10

iii nearest 1

a 420

b 24

c 200

d 4200

e 2400

f 400

13 A shop sells bags of rice that have a mass of 500g measured to the nearest 10 g.

- a** For the mass of one bag of rice, write
- i** the lower bound

ii the upper bound

iii an inequality to show the range of values.

- b** Nikau buys two bags of rice.
- i** Work out the lower bound for the mass of the two bags of rice.

ii Work out the upper bound for the mass of the two bags of rice.

Explain how you worked out your answers.

Tip

For part **b**, use your answers to part **a**.

14 A shop sells pieces of wood that measure 150cm to the nearest 10cm.

- a** For the length of one piece of wood, write
- i** the lower bound

ii the upper bound

iii an inequality to show the range of values.

- b** Carlos and Pepe want to find the range of values for the total length of three pieces of wood.

This is what they write.

Carlos

Lower bound: $3 \times 145 = 435 \text{ cm}$

Upper bound: $3 \times 155 = 465 \text{ cm}$

Range of values: $435 \text{ cm} \leq x < 465 \text{ cm}$

Pepe

One piece of wood = 150 cm

Three pieces of wood = $3 \times 150 = 450 \text{ cm}$

Range of values: $445 \text{ cm} \leq x < 455 \text{ cm}$

Who has worked out the correct answer?

Explain why their method is correct.

Explain the mistake the other person has made.

15 A bottle has a capacity of 1.2 litres correct to the nearest 0.1 litres.

a For the capacity of one bottle, write

i the lower bound

ii the upper bound

iii an inequality to show the range of values.

b For the capacity of five bottles, write

i the lower bound

ii the upper bound

iii an inequality to show the range of values.

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25 YEARS

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We are working with Cambridge Assessment International Education towards endorsement of this title.

inequalities

4.1 Constructing and solving equations

Exercise 4.1

Focus

Key words

construct

solve

1 Copy and complete the workings to solve these equations.

a $2x - 6 = 10$

$$2x = 10 + 6$$

$$2x = \square$$

$$x = \frac{\square}{2}$$

$$x = \square$$

b $4(3x + 2) = 32$

$$12x + \square = 32$$

$$12x = 32 - \square$$

$$12x = \square$$

$$x = \frac{\square}{12}$$

$$x = \square$$

c $\frac{y}{2} - 3 = 1$

$$\frac{y}{2} = 1 + \square$$

$$\frac{y}{2} = \square$$

$$y = \square \times 2$$

$$y = \square$$

d $5y + 3 = 9 + 2y$

$$5y - 2y = 9 - \square$$

$$\square y = \square$$

$$y = \frac{\square}{\square}$$

$$y = \square$$

2 Copy and complete the workings to solve these equations.

a $5 - 2x = 9$

$$-2x = 9 - \square$$

b $6(3 - x) = 3x$

$$\square - 6x = 3x$$

$$\begin{aligned} -2x &= \square \\ x &= \frac{\square}{-2} \\ x &= \square \end{aligned}$$

$$\begin{aligned} \square &= 3x + 6x \\ \square &= 9x \\ \frac{\square}{9} &= x \\ x &= \square \end{aligned}$$

c $\frac{3y}{4} + 1 = 7$

$$\begin{aligned} \frac{3y}{4} &= 7 - \square \\ \frac{3y}{4} &= \square \\ 3y &= \square \times 4 \\ 3y &= \square \\ &= \square \\ y &= \frac{\square}{3} \\ y &= \square \end{aligned}$$

d $3(y + 5) = 2(20 - y)$

$$\begin{aligned} 3y + \square &= 40 - \square y \\ 3y + \square y &= 40 - \square \\ \square y &= \square \\ y &= \frac{\square}{\square} \\ y &= \square \end{aligned}$$

3 Copy and complete the workings to solve these equations.

a $\frac{30}{x} = 5$

$$\begin{aligned} 30 &= 5x \\ \frac{30}{\square} &= x \\ x &= \square \end{aligned}$$

b $\frac{63}{y+1} = 9$

$$\begin{aligned} 63 &= 9(y+1) \\ \frac{63}{\square} &= y+1 \\ \square &= y+1 \\ \square - 1 &= y \\ y &= \square \end{aligned}$$

Practice

4 Solve these equations.

a $3g - 5 = 31$

b $-3g - 5 = 25$

c $7 + 4p = 28 + p$

d $-5 + 3g = 16$

e $15 = 40 - 5y$

f $6(y - 7) = 30$

g $0 = 17(15 + 5x)$

h $5(x + 5) + 3(x - 2) = 3$



5 Here is an equation: $5(x + 3) = 10x - 20$

a Solve the equation by first multiplying out the brackets.

b Solve the equation by first dividing by 5.

c Which method do you prefer? Explain why.

6 Here is an equation: $8(x - 4) + 4(5 - x) = 0$

a Solve the equation by first multiplying out the two brackets.

b Solve the equation by first dividing by 4.

c Which method do you prefer? Explain why.

7 This is part of Cain's homework.

Question Solve $5(x + 4) = 2(30 - x)$

Answer $5x + 9 = 60 - 2x$

$$5x - 2x = 60 + 9$$

$$3x = 69$$

$$x = \frac{69}{3} = 23$$

a Use the answer, $x = 23$, to show that Cain's working is incorrect.

b Work through Cain's working and explain all the mistakes he has made.

c Work out the correct answer, and show how to check that your answer is correct.

8 Solve these equations. Check each answer by substituting the answer back into the equation.

a $\frac{105}{q} = 5$

b $\frac{3}{b} = 12$

c $\frac{36}{c + 2} = 9$

d $\frac{15}{d - 4} = 25$

9 Two numbers are n and $2(n + 3)$.

a The sum of the numbers is 90. **Construct** an equation to show this.

b Solve your equation.

c Work out the two numbers.

4 Equations and inequalities

10 Marcus is thinking of a number.

a Write an equation to show this situation.

b Find the original number.

If you subtract 8 from my number and then



b Find the original number.

multiply by 5, you get the same answer as if you add 10 to my number and then multiply by 2.



- 11 Elin shares \$180 between her grandchildren. They each get \$36.

a Which two of these equations represent the situation?

A $\frac{x}{180} = 36$

B $\frac{180}{x} = 36$

C $180x = 36$

D $\frac{36}{x} = 180$

E $36x = 180$

b Solve all of the equations in part a. Use your answers to decide if you chose the correct two equations in part a.

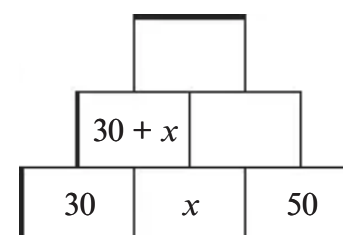
Challenge

- 12 In this algebra wall, each number or expression is the sum of the two numbers or expressions below it.

a Write expressions for the numbers in the two empty cells.

b The number in the top cell is 144. Write an equation to show this.

c Solve your equation in part b.



- 13 The length of the first side of a triangle is s cm. The length of the second side is twice the length of the first side. The length of the third side is 5 cm more than the length of the second side. The perimeter of the triangle is 1 metre.

a Write an equation to show this situation.

b Solve your equation in part a.

c Find the length of the longest side of the triangle.

- 14 Read what Sofia says.

a Write an equation to show this situation.

b Solve your equation in part a.

c How old is Sofia's father?

I am y years old.
My mother's age is 3 times my age. My brother is 2 years younger than me. My father's age is 4 times my brother's age. The total of our four ages is 116 years.



- 15 a The length of one side of a square is a cm. Another side is $3(a - 2)$ cm long.
- i Write an equation to show this situation.
- ii What are the lengths of the sides of the square?

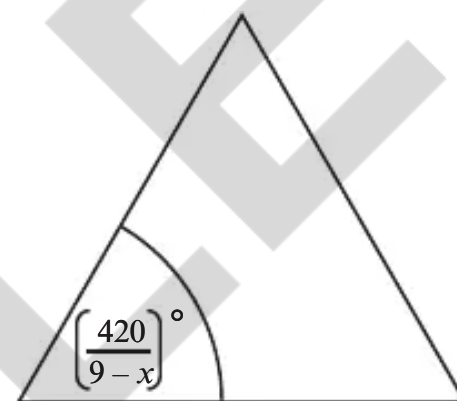
Tip

What is special about the lengths of the sides of a square?

- b The length of the shorter side of a rectangle is a cm.
The length of the longer side of the rectangle is $3(a - 2)$ cm. The perimeter is 44 cm.
- i Write an equation to show this situation.
ii What are the lengths of the sides of the rectangle?

- 16 The diagram shows the size of one of the angles in an equilateral triangle.

- a Write an equation to represent the problem.
b Solve your equation to find the value of x .



of the sides of a square?

> 4.2 Simultaneous equations

Exercise 4.2

Focus

- 1 Copy and complete the workings to solve the **simultaneous equations** $y = 2x - 1$ and $y = x + 5$ by the **method of substitution**.

- ① Work out x .

$$2x - 1 = x + 5$$

$$2x - \square = 5 + \square$$

$$x = \square$$

- ② Work out y .

$$y = 2x - 1$$

$$= 2 \times \square - 1$$

$$= \square - 1$$

$$= \square$$

- ③ Check values are correct.

$$y = x + 5$$

$$\square = \square + 5$$

$$\square = \square$$

- ④ Write the answers:

$$x = \square \text{ and } y = \square$$

Key words

method of
elimination
method of
substitution
simultaneous
equations

- 2 Copy and complete the workings to solve the simultaneous equations $y = 6x + 3$ and $y = 2x - 9$.

- ① Work out x .

$$6x + 3 = 2x - 9$$

- ② Work out y .

$$y = 6x + 3$$

- ③ Check values are correct.

$$y = 2x - 9$$

$$\begin{aligned}
 6x - \square &= -9 - \square & = 6 \times \square + 3 & \square &= 2 \times \square - 9 \\
 \square x &= \square & = \square + 3 & \square &= \square - 9 \\
 x &= \frac{\square}{\square} = \square & = \square & \square &= \square
 \end{aligned}$$

④ Write the answers: $x = \square$ and $y = \square$

3 a Copy and complete the table of values for each equation.

$$y = 2x + 1$$

x	0	2	4
y			

$$y = x + 4$$

x	0	2	4
y			

b On graph paper, draw a coordinate grid from 0 to 4 on the x -axis and 0 to 10 on the y -axis.

Plot the points from your tables on the grid and draw the straight lines $y = 2x + 1$ and $y = x + 4$.

c Write the coordinates of the point where your two lines intersect. Use your coordinates to write the solution to the simultaneous equations $y = 2x + 1$ and $y = x + 4$.

d Copy and complete the workings to solve the simultaneous equations $y = 2x + 1$ and $y = x + 4$ algebraically.

① Work out x .

$$2x + 1 = x + 4$$

$$2x - \square = 4 - \square$$

$$x = \square$$

② Work out y .

$$y = 2x + 1$$

$$= 2 \times \square + 1$$

$$= \square + 1$$

$$= \square$$

③ Check values are correct.

$$y = x + 4$$

$$\square = \square + 4$$

$$\square = \square$$

④ Write the answers: $x = \square$ and $y = \square$

e Check that your answers to parts c and d are the same.

4 Copy and complete the workings to solve these simultaneous equations using the **method of elimination**.

a $x + y = 10$ and $x - y = 4$

① Add the two equations.

② Substitute $x = \square$ into first equation

$$x + y = 10$$

$$+ \frac{x - x}{2} = 4$$

$$2x + 0y = \square$$

$$2x = \square, x = \frac{\square}{2} = \square$$

③ Check in second equation

$$\square - \square = \square$$

b $x + 5y = 28$ and $x + 3y = 18$

① Subtract the two equations.

$$x + 5y = 28$$

$$- \frac{x + 3y}{2} = 18$$

$$0x + 2y = \square$$

$$2y = \square, y = \frac{\square}{2} = \square$$

③ Check in second equation

$$\square + 3 \times \square = \square$$

c $3x + 2y = 34$ and $x - 2y = 6$

① Add the two equations.

$$3x + 2y = 34$$

$$+ \frac{x - 2y}{2} = 6$$

$$4x + 0y = \square$$

$$4x = \square, x = \frac{\square}{4} = \square$$

③ Check in second equation

$$\square - 2 \times \square = \square$$

$$\square + y = 10$$

$$y = 10 - \square$$

$$= \square$$

④ Write the answers:

$$x = \square \text{ and } y = \square$$

② Substitute $y = \square$ into first equation

$$x + 5 \times \square = 28$$

$$x = 28 - \square$$

$$= \square$$

④ Write the answers:

$$x = \square \text{ and } y = \square$$

② Substitute $y = \square$ into first equation

$$3 \times \square + 2y = 34$$

$$2y = 34 - \square$$

$$2y = \square, y = \frac{\square}{2} = \square$$

④ Write the answers:

$$x = \square \text{ and } y = \square$$

Practice

5 Solve these simultaneous equations.

$$y = 3x$$

$$y = x + 12$$

6 Solve these simultaneous equations.

$$y = 2x + 1$$

$$y = -2x + 9$$

4 Equations and inequalities

7 Solve these simultaneous equations.

$$y = 3 - x$$

$$y = 2x - 15$$

8 a Here are some simultaneous equations: $y = 4x - 3$ and $y = x + 3$

Solve the equations using

i a graphical method

Tip

For the graphical method, use the same method as

ii an algebraic method.

b Check your answers to parts ai and aii are the same.

c Which method do you prefer, the graphical or the algebraic method? Explain why.

9 Solve these simultaneous equations using the method of elimination.

a $x + y = 20$
 $x - y = 16$

b $3x + y = 30$
 $2x - y = 15$

c $x + 2y = 21$
 $3x - 2y = 15$

d $3x + 2y = 64$
 $x + 2y = 40$

10 Solve each pair of simultaneous equations. Use your favourite algebraic method.

a $x = y - 10$
 $y = 2x$

b $y + x = 27$
 $y = 4(x + 3)$

c $2x + 3y = 1$
 $y = 5 - x$

d $y = 12 + 4x$
 $x + 2y = 6$

in Question 3.
For the algebraic
method, use the
same method as in
questions 1 and 2.

Challenge

11 Den buys 2 cakes and 3 coffees and it costs him \$9. Ang buys 2 cakes and 1 coffee and it costs her \$5.

Let x represent the cost of a cake and y represent the cost of a coffee.

a Write two equations to represent the information.

b Solve your equations to find the cost of a cake and the cost of a coffee.

12 Xavier buys two items. He receives \$2.26 change from \$40.

The difference between the prices of the two items is \$9.24.

a Write two equations to represent the information.

b Solve your equations to find the cost of each item.

13 $x + y = 21$ and $x - y = 5$

Work out the value of $2x + 3y$.



14 Here are six equation cards.

$6(e - 2) = f + 7$

$2a - b = 15$

$3c + 2d = 32$

$a = 3b$

$3c - d = 2$

$3f - 6e = 3$

Show that

a the mean value of a, b, c, d, e and f is 7

b the range in the values of a, b, c, d, e and f is 8.

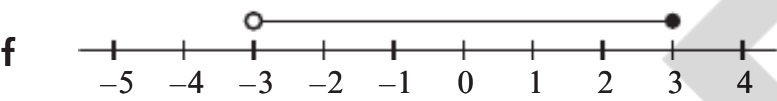
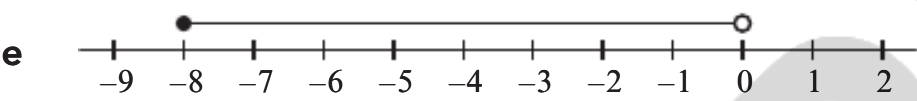
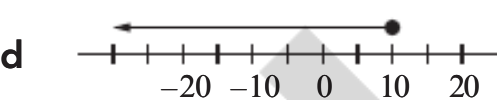
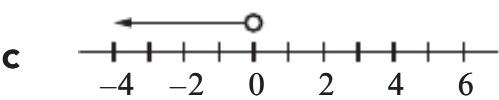
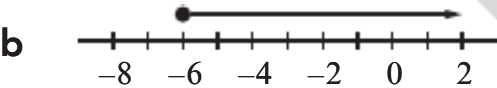
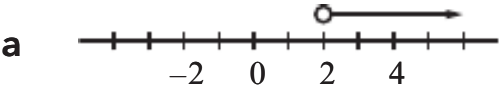
> 4.3 Inequalities

Exercise 4.3

Focus

inequality
solution set

1 Write the **inequality** for each **solution set**.



2 Show each of these solution sets on a number line.

- a $x \geq -2$ b $x < 3.5$ c $x \leq -3$
d $x > 10$ e $1 < x \leq 6$ f $-4 \leq x < 4$

3 N is an integer. Work out

- a the smallest possible value of N when $N \geq 8.2$
b the largest possible value of N when $N < -5$
c the possible values of N when $-3 \leq N < 2.5$

4 N is an integer and $N \leq 4$

For each statement say whether it

- must be true could be true cannot be true

- a $N = 4$ b $N < 0$ c $N < 5$ d $N \geq 5$

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4 Equations and inequalities

5 Copy and complete the solutions to these inequalities.

- a $6x > 18$ b $2x - 3 < 19$ c $5x + 1 \leq -9$ d $3(x - 4) \geq 9$
 $x > \frac{18}{6}$ $2x < 19 + \square$ $5x \leq -9 - \square$ $3x - \square \geq 9$
 $x > \square$ $2x < \square$ $5x \leq \square$ $3x \geq 9 + \square$

$$x < \frac{\square}{2}$$

$$x < \square$$

$$x \leq \frac{\square}{5}$$

$$x \leq \square$$

$$3x \geq \square$$

$$x \geq \square$$

$$x \geq \frac{3}{\square}$$

Practice

6 Solve these inequalities.

a $10x \geq 5$

b $4x + 10 < 22$

c $5(x - 7) \leq 30$

d $15 > 2(x + 1)$

7 Show each solution set in Question 6 on a number line.

8 a Show that the solution set to the inequality $3(y - 4) + 7y \geq 8y - 5$ is $y \geq 3.5$

b Substitute these values for y into $3(y - 4) + 7y \geq 8y - 5$ to show that the solution set is correct.

i $y = 3$

ii $y = 3.5$

iii $y = 4$

9 Solve these inequalities. Check each solution set.

a $4x - 5 \leq 2x + 15$

b $x + 6 > 14 - x$

c $5(2 + x) \leq 10x$

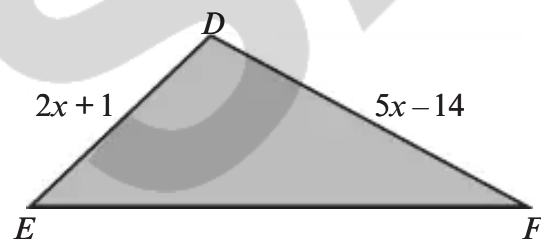
d $\frac{x}{4} - 1 < 4$

10 The diagram shows triangle DEF . Side length DF is greater than side length DE .

a Write an inequality to show this information.

b Solve your inequality.

c Check your solution is correct.



11 Copy and complete the solutions to these inequalities.

a $3x > 4x + 12$

b $3x - 3 < 5x - 17$

c $6 - 5x \leq -12$

$3x - 4x > \square$

$3x - 5x < -17 + \square$

$-5x \leq -12 - \square$

$-x > \square$

$-2x < \square$

$-5x \leq \square$

$$\frac{-x}{-1} < \frac{\square}{-1}$$

$$x < \square$$

$$\frac{-2x}{-2} > \frac{\square}{-2}$$

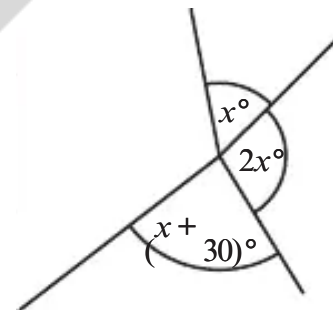
$$x > \square$$

Tip

Remember, when you divide by a negative number you must change the inequality sign.

Challenge

- 12 The diagram shows four angles round a point.
- Write an inequality for x .
 - Solve the inequality.
 - Can the angle labelled x° be a right angle? Explain your answer.



- 13 Xavier has 100 dollars. He gives A dollars to his brother. He gives his sister 5 dollars more than he gives his brother. He gives his friend twice as much as he gives his sister. He still has some money left.

- Write an inequality for A .
- Solve the inequality.
- Can Xavier give his friend 55 dollars? Explain your answer.

- 14 The angles of a quadrilateral add up to 360° . Three of the angles, in degrees, are x , $2x$ and $3(x - 10)$.

- Write an inequality for x .
- Solve the inequality.
- Could the angles that are $2x$ degrees and $3(x - 10)$ degrees be the same size?

Give a reason for your answer.

- 15 You are given that $z > 2$. Write an inequality for each expression.

- $2z + 9$
- $3(z - 4)$
- $4 + 2z$
- $5(3z - 2)$

- 16 Solve these inequalities. Represent each answer on a number line.

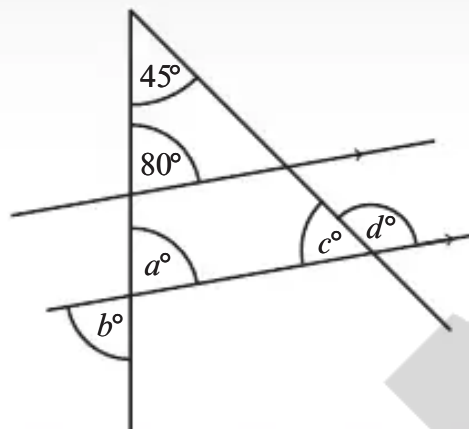
- $3 < x + 3 \leq 10$
- $0 \leq y - 2 \leq 8$
- $-2 < 2n < 6$
- $0 < 4m < 18$

> 5.1 Calculating angles

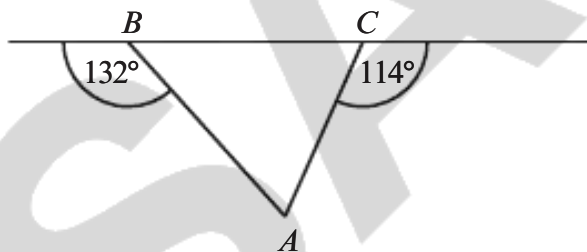
Exercise 5.1

Focus

- 1 Work out the values of a , b , c and d .

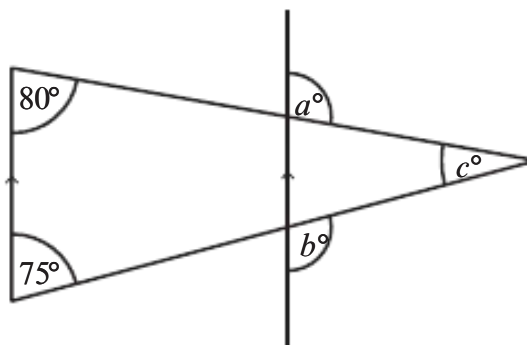


- 2 Which of these could be the angles of a quadrilateral?
A $70^\circ, 80^\circ, 90^\circ, 100^\circ$ **B** $60^\circ, 80^\circ, 90^\circ, 130^\circ$ **C** $50^\circ, 80^\circ, 105^\circ, 125^\circ$
- 3 Show that ABC is an isosceles triangle.



Practice

- 4 Work out the values of a , b and c .

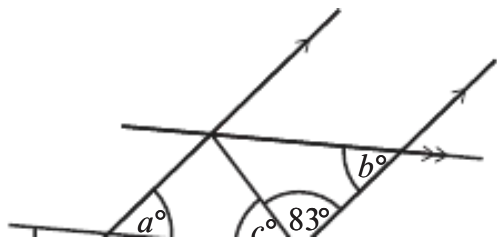


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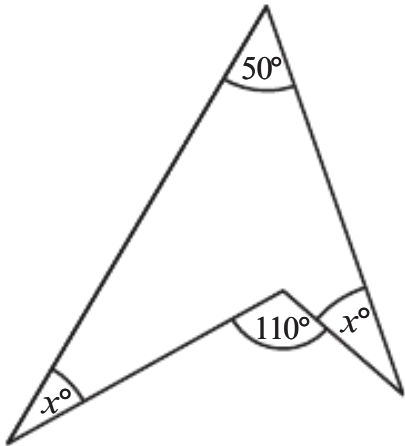
5.1 Calculating angles

- 5 Work out the values of a , b and c .





6 This shape has two equal angles.

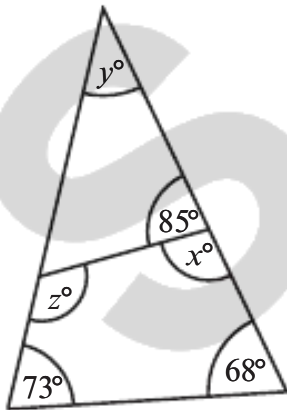


Work out the value of x .

- 7 Two angles of a triangle are 45° and 60° .
- a Sketch the triangle.
 - b Show the exterior angles of the triangle and their sizes.

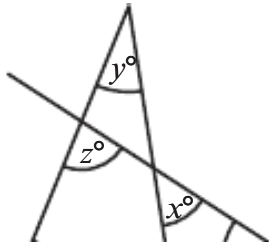
Challenge

8 Work out the values of x , y and z .



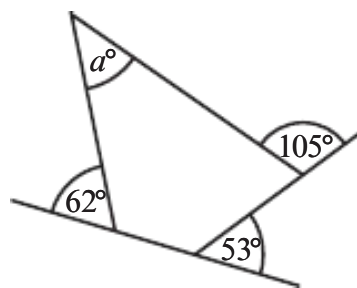
5 Angles

9 Work out the values of x , y and z .

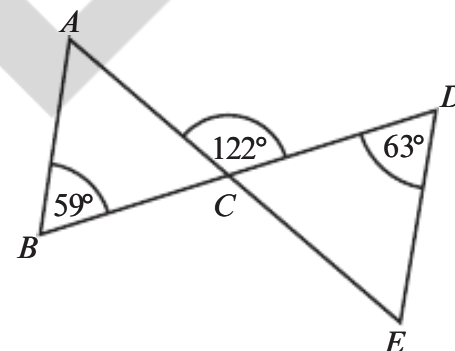




- 10 Work out the value of a . Explain your method.



- 11 a Show that AB and DE are not parallel.
b Show that triangles ABC and CDE have angles of the same size.



> 5.2 Interior angles of polygons

Exercise 5.2

Focus

Key words

regular polygon

- 1 Work out the sum of the interior angles of a polygon with
a 4 sides b 8 sides c 12 sides.
- 2 a Show that the sum of the interior angles of a pentagon is 540° .
b Four of the interior angles of a pentagon are 120° . Work out the fifth angle.
c Four of the interior angles of a pentagon are 108° . Is it a regular polygon? Give a reason for your answer.

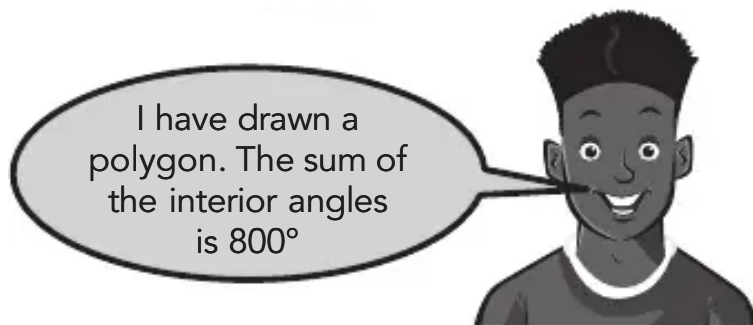
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5.2 Interior angles of polygons

- 3 A nonagon is a polygon with 9 sides.
a Work out the sum of the interior angles of a nonagon.
b Work out the interior angle of a regular nonagon.
- 4 a The sum of the interior angles of a polygon is 900° .
How many sides does the polygon have?

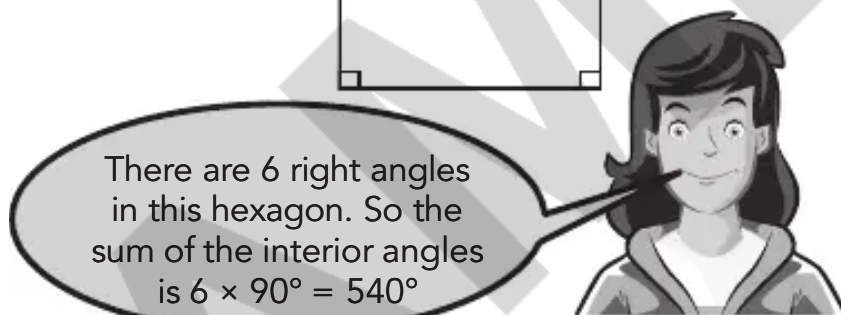
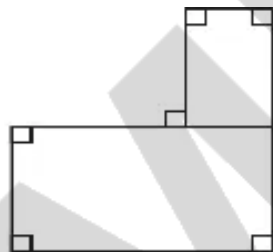
b Marcus says:



Explain why this is impossible.

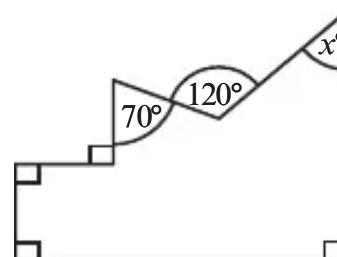
Practice

- 5 Look at this diagram.
Sofia says:



What mistake has Sofia made?

- 6 The interior angles of a pentagon are x° , $(x + 20)^\circ$, $(x + 20)^\circ$, $(x + 20)^\circ$, $(x + 40)^\circ$ and $(x + 40)^\circ$. Work out the value of x .
- 7 a Work out the sum of the angles of this shape.
b Work the value of x .



- 8 Show that the sum of the angles of a polygon could be 1800° but could not be 2000° .

Challenge

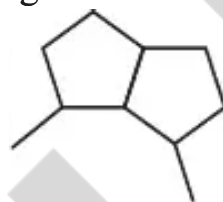
- 9 a Show that it is possible for two regular octagons and a square to fit round a point as shown in the diagram.
b i Show that it is possible to arrange a mixture of regular hexagons and equilateral triangles around a point.



ii In how many ways can you do this?

10 a Work out the sum of the interior angles of a decagon.

b This diagram shows two regular pentagons and part of another regular shape arranged round a point. Show that the third shape is a decagon.

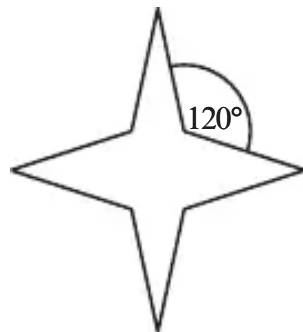


Tip

A decagon has 10 sides.

11 This star has 4 lines of symmetry and rotational symmetry of order 4.

Work out the angle of each point.



12 The shape in the centre of this star is a **regular polygon**.

Work out the angle of each point.



13 Zara says:

An expression for the sum of the interior angles of a polygon with n sides is $90(2n - 4)^\circ$.



Test this conjecture.

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5.3 Exterior angles of polygons

> 5.3 Exterior angles of polygons

Exercise 5.3

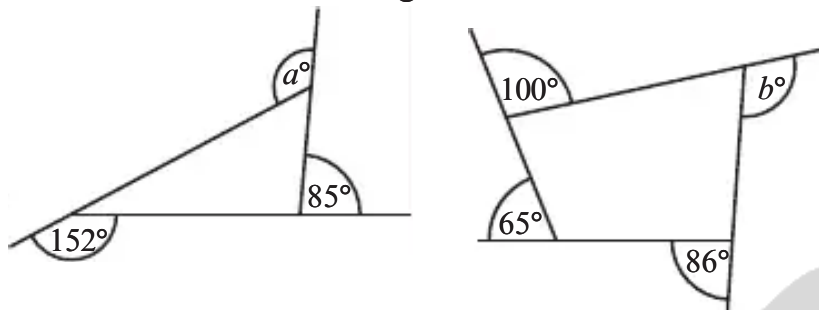
Focus

Key words

exterior angle of a polygon

a polygon

- 1** Calculate the lettered angles.

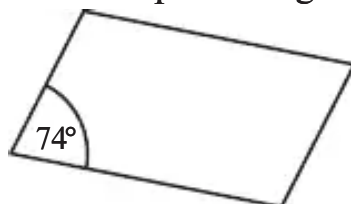


- 2** Work out the **exterior angle** of

- a** a square

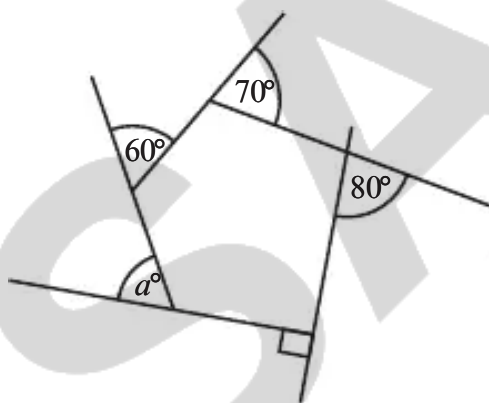
- b** an equilateral triangle.

- 3** This is a parallelogram.



Work out the exterior angles.

- 4** Work out the value of a .



Practice

- 5** All the exterior angles of a pentagon are equal. What size is each angle?

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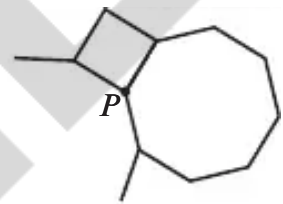
5 Angles

- 6** Work out the number of sides of a regular polygon when the exterior angle is
 - a** 60°
 - b** 45°
 - c** 40°
 - d** 36°
- 7** Explain why the exterior angle of a regular polygon could be 20° , 30° or 40° but could not be 50° .
- 8** The interior angle of a regular polygon is 170° .

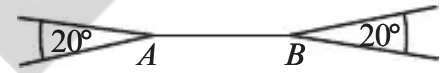
- a Work out the exterior angle.
- b Work out the number of sides.

Challenge

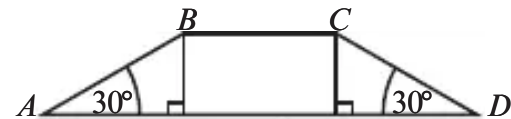
- 9 A square, a regular hexagon and another regular polygon meet at P .
Work out the number of sides of the other regular polygon.



- 10 Two identical regular polygons meet along AB .
Work out the number of sides of each polygon.



- 11 AB , BC and CD are three sides of a regular polygon.
How many sides does the polygon have? Justify your answer.



- 12 Three of the exterior angles of a hexagon are x° and the other three exterior angles are $(x + 10)^\circ$. Work out the value of x .
- 13 The exterior angles of an octagon are y° , $(y + 2)^\circ$, $(y + 4)^\circ$, $(y + 6)^\circ$, $(y + 8)^\circ$, $(y + 10)^\circ$, $(y + 12)^\circ$ and $(y + 14)^\circ$. Work out the largest interior angle of the octagon.

> 5.4 Constructions

Exercise 5.4

Do not use a protractor in constructions in this exercise.

Key word

inscribe

Focus

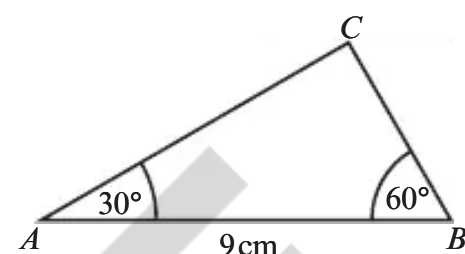
- 1
 - a Draw a circle with radius 6 cm.
 - b **Inscribe** a square in the circle.
 - c Check that each side of the square is 8.5 cm. If you made an error of more than 2 mm, draw your diagram again.

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5.4 Constructions

- 2
 - a Construct an equilateral triangle with side length 10 cm.
 - b Check the angles with a protractor.
- 3
 - a Construct an accurate copy of triangle ABC .
 - b Check that $AC = 7.8$ cm and $BC = 4.5$ cm. If you made an error of more than 2 mm, draw the triangle again.



Practice

- 4

a

Construct an accurate copy of triangle DEF .
- b

Check that $EF = 4.6$ cm.
- 5

a

Draw a circle with radius 8 cm.
- b

Inscribe an equilateral triangle in the circle.
- c

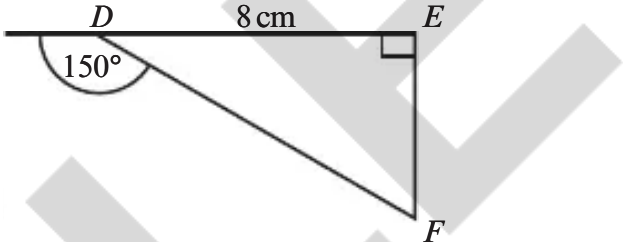
Check that the length of each side of the triangle is 15.6 cm.
- 6

a

Draw a circle with radius 7 cm.
- b

Inscribe a regular hexagon in the circle.
- c

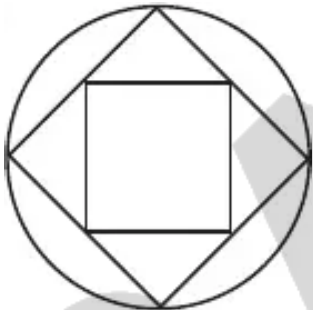
Measure the sides and angles of the hexagon to check your accuracy.



Challenge

- 7

Construct a copy of this pattern.

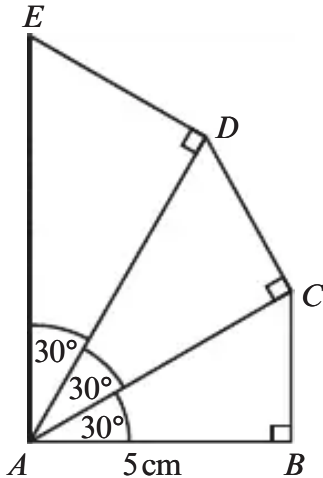


- 8

a

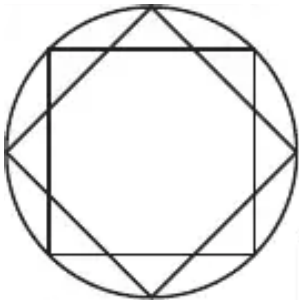
$AB = 5$ cm. Construct an accurate copy of this diagram.
- b

Measure AE . It should be 7.7 cm. How accurate is your construction?

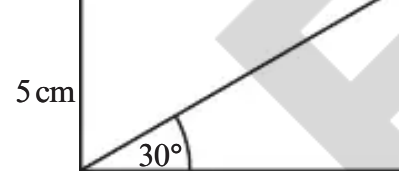


- 9

Construct a copy of this pattern.



- 10 Here is a rectangle.
- Construct an accurate copy of the rectangle.
 - Measure the diagonal.



> 5.5 Pythagoras' theorem

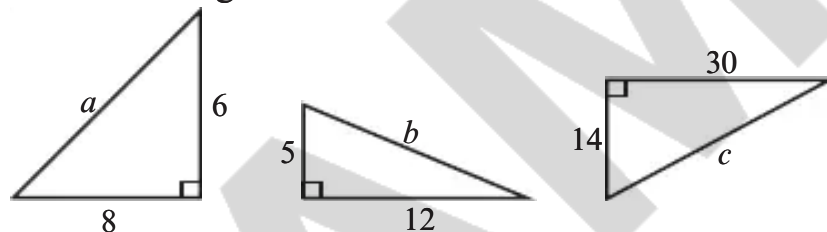
Exercise 5.5

Focus

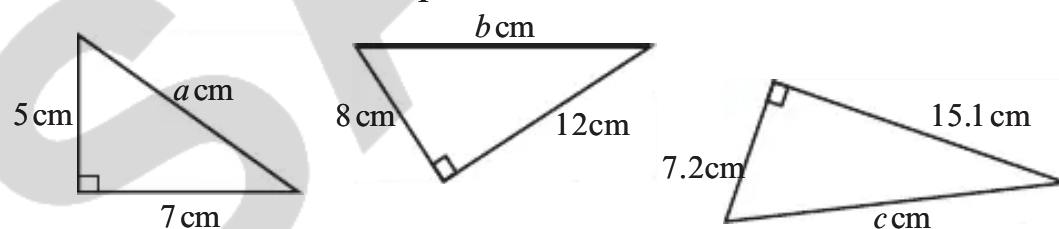
Key words

hypotenuse
Pythagoras'
theorem

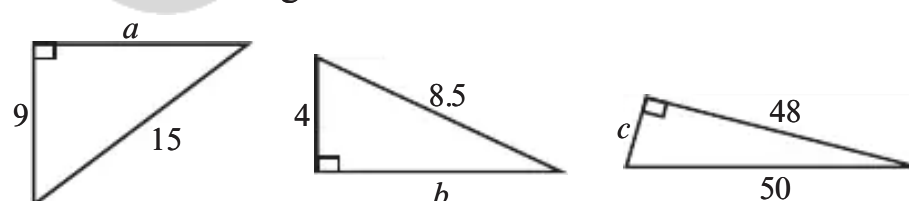
- 1 Use **Pythagoras' theorem** to calculate the length of the **hypotenuse** of each triangle.



- 2 Calculate the length of the hypotenuse of each triangle. Round each answer to 1 decimal place.



- 3 Calculate the length of each lettered side.

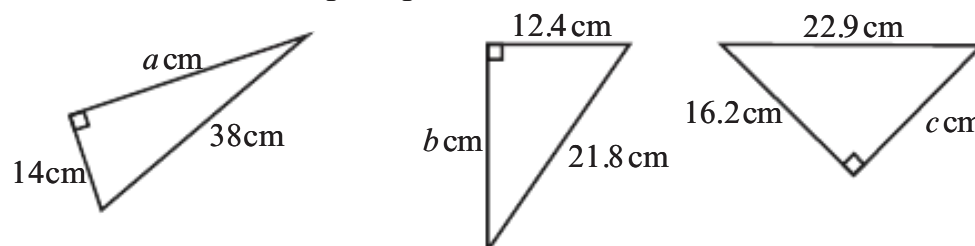


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5.5 Pythagoras' theorem

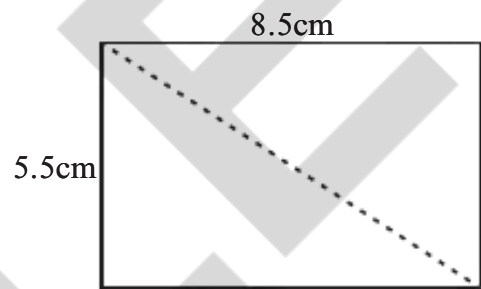
- 4 Calculate the missing lengths. Round each answer to 1 decimal place.



Practice

5 The sides of a rectangle are 5.5 cm and 8.5 cm as shown in the diagram.

- a Calculate the length of the diagonal.
- b Make an accurate drawing to check your answer.

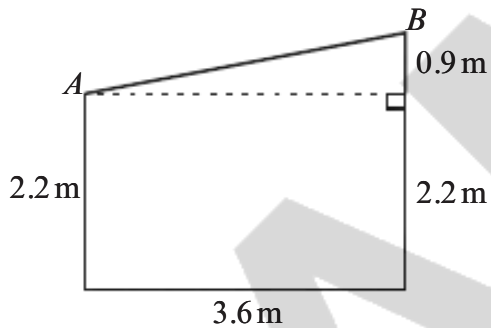


6 a Calculate the length of the diagonal of a square when the length of each side is

- i 3 cm ii 5 cm iii 8 cm iv 10 cm

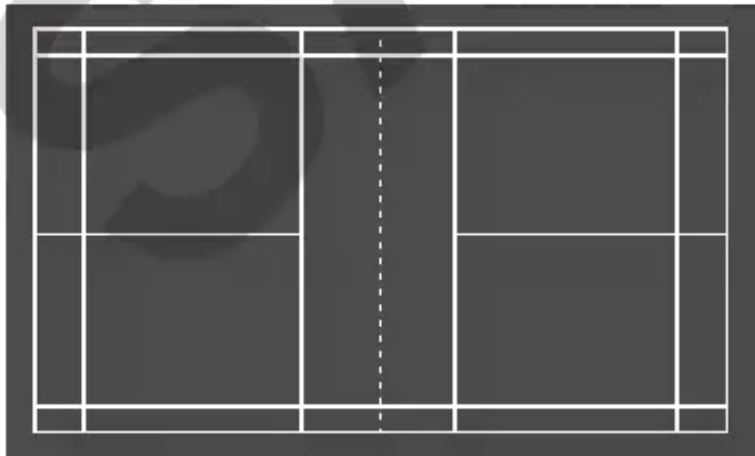
b Test the conjecture that the diagonal of a square is always $\sqrt{2} \times$ the length of the side.

7 The diagram shows the side view of a building.



Calculate the length of AB .

8 A badminton court is 6.1 m wide and 13.4 m long.



Calculate the distance from one corner to the opposite corner.

5 Angles

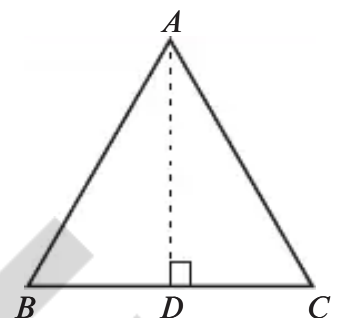
Challenge

9 ABC is an equilateral triangle. Each side is 20 cm.

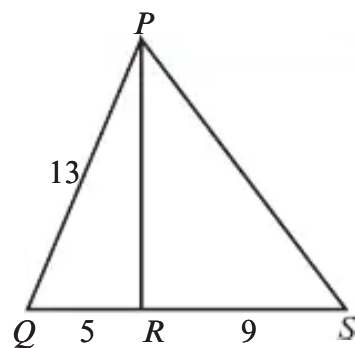
Work out

- a the height AD
- b the area of the triangle.

10 a Work out the length of PR .



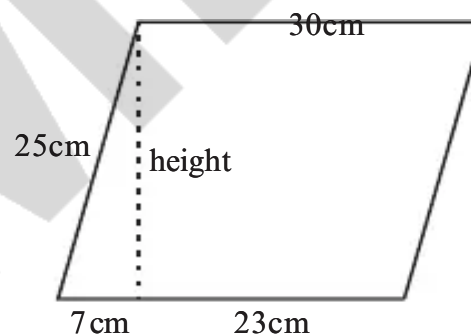
- b** Use your answer to part **a** to work out the length of PS .



- 11** An A4 sheet of paper is 21.0 cm wide and 29.7 cm long.
Find the length of the longest straight line you can draw on the paper.

- 12** This is a parallelogram.
Work out

- a** the height of the parallelogram
b the area of the parallelogram.



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6

Statistical investigations

> 6.1 Data collection and sampling

Exercise 6.1

Focus

- ✦ 1 You are going to investigate how long learners in your school spend playing computer games.
- a Age is one factor that could affect this. Write two other factors.
 - b Write three questions you could ask.
 - c Write two predictions you could test.
 - d Describe two different ways to take a sample.
 - e Which of the two methods from part **d** is better? Give a reason for your answer.

Practice

- ✦ 2 You are going to investigate the number of passengers in cars on a busy road.
- a What factors can affect the number of passengers?
 - b Write three questions you could ask about the number of passengers.
 - c Write two predictions you could test.
 - d Describe some different ways of choosing a sample of cars to test your predictions.
 - e Which sample method from part **d** is best? Give a reason for your answer.

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6 Statistical investigations

Challenge

- ✦ 3 You are going to investigate the speed with which people can write either on paper or using a keyboard.
- a Write some questions you could ask about writing speed.
 - b Write some predictions you could test.
 - c Describe some different ways of choosing a sample to test your predictions.

- d** Which sample method from part **c** is best? Give a reason for your answer.
- e** Carry out a small trial of your investigation. Can you think of ways to improve the investigation?

› 6.2 Bias

Key word

bias

Exercise 6.2

Focus

- 1** At a concert, 56% of people in the audience are female and 44% are male.

You want a representative sample of 60 people. How many people in your sample should be

- a** female **b** male.

- 2** You want a representative group of five learners from a class.

You ask the teacher to choose five learners.

- a** Why could this sample be **biased**?

- b** Describe two better ways to choose a sample.

- 3** A radio programme asks listeners to phone in and give their opinions of an insurance company. 72% of the people who phone have negative opinions of the company.

- a** Why could this be a biased sample?

- b** Describe a better way to get a sample of opinions.

Practice

- 4** Here are three ways of testing the prediction that people in a town are in favour of building a new shopping centre. Give an advantage and a disadvantage of each method.

- a** Using social media
- b** Sending letters to people
- c** Asking people in the street

5 This table shows the ages of people who live in a village.

Age	Under 18	18 to 55	Over 55
Number of people	73	327	128

You want a representative sample of 50 people.

How many people from each age group should be in the sample?

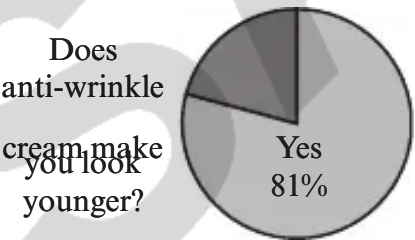
6 Look at this advert.

81% of women found that anti-wrinkle cream made them look younger.

Based on a sample of 48 women using the cream for a month

- a Does the advert prove that anti-wrinkle cream works?
- b Write three questions you could ask to check whether this result is reliable.

The results could be illustrated in a pie chart as shown.



- c What important information is missing from the diagram?

6 Statistical investigations

Challenge

- 7 Here are three different questions in a survey.
1. Do you eat five fruit or vegetable portions a day?
 2. Do you eat too much meat?
 3. Do you agree that people are overweight because they are greedy and eat too much?
- a Explain why each question could give biased results.

- b Describe a better way of writing each question.
- 8 In a large group of teachers, 40% are men and 60% are women. You have collected data from 28 men. How many women do you need to collect data from to make it a representative sample?
- 9 You want to do a survey of the parents of 50 learners in your school. How will you choose a representative sample?



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7

Shapes and measurements

> 7.1 Circumference and area of a circle

Remember these formulae:

$C = \pi d$ where: C is the **circumference** of the circle
 d is the **diameter** of the circle.

$A = \pi r^2$ where: A is the **area** of the circle
 r is the **radius** of the circle.

Tip

Remember that:

diameter =
radius $\times 2$

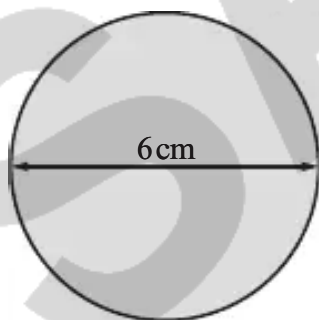
radius =
diameter $\div 2$

Exercise 7.1

Focus

- 1 Copy and complete the workings to work out the circumference of each circle. Use $\pi = 3.14$

a

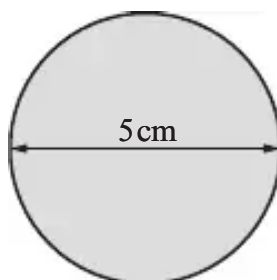


$$d = 6 \text{ cm}$$

$$C = \pi \times d = \pi \times 6$$

$$= \boxed{} \text{ cm}$$

b

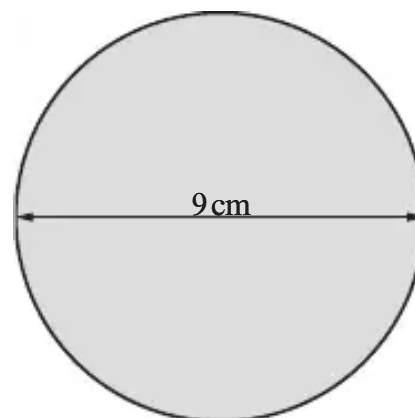


$$d = 5 \text{ cm}$$

$$C = \pi \times d = \pi \times \boxed{}$$

$$= \boxed{} \text{ cm}$$

c



$$d = \boxed{} \text{ cm}$$

$$C = \pi \times d = \pi \times \boxed{}$$

$$= \boxed{} \text{ cm}$$

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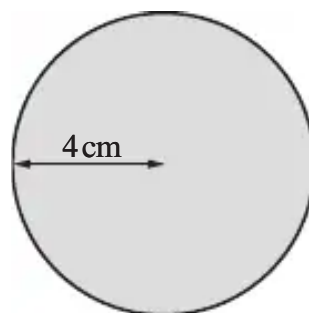
7 Shapes and measurements

- 2 Copy and complete the working to work out the circumference of this circle.

Use $\pi = 3.142$. Round your answer correct to 2 decimal places (2 d.p.).

radius, $r = 4 \text{ cm} \rightarrow$ diameter, $d = 2 \times 4 = \boxed{} \text{ cm}$

$$C = \pi \times d = \pi \times \boxed{} = \boxed{} \text{ cm}$$



Tip

Remember that the diameter is twice the radius.

- 3 Copy and complete the working to work out the perimeter of this semicircle.



Use $\pi = 3.142$. Round your answer correct to 2 decimal places (2 d.p.).

perimeter of semicircle = diameter + (circumference of the circle $\div 2$)

Work out the circumference of the circle first:

$$C = \pi \times d = \pi \times 12 = \boxed{} \text{ cm}$$

$$\text{circumference} \div 2 = \boxed{} \div 2 = \boxed{} \text{ cm}$$

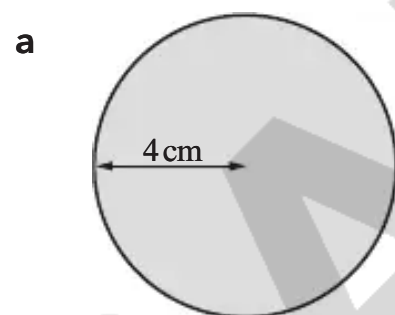
$$\text{perimeter} = 12 + \boxed{} = \boxed{} \text{ cm}$$



Tip

The perimeter of the semicircle is the distance around the outside. This is the diameter plus half of the circumference of the circle.

- 4 Copy and complete the workings to work out the area of these circles. Use $\pi = 3.14$.

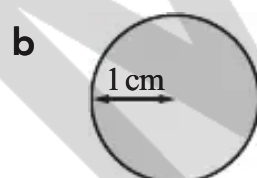


$$r = 4 \text{ cm}$$

$$A = \pi \times r^2 = \pi \times 4^2$$

$$= \pi \times 16$$

$$= \boxed{} \text{ cm}^2$$

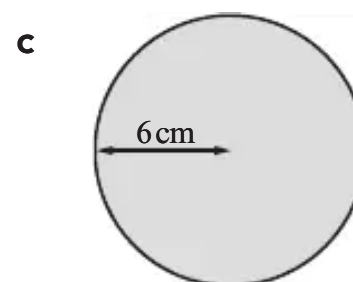


$$r = 1 \text{ cm}$$

$$A = \pi \times r^2 = \pi \times 1^2$$

$$= \pi \times \boxed{}$$

$$= \boxed{} \text{ cm}^2$$



$$r = \boxed{} \text{ cm}$$

$$A = \pi \times r^2 = \pi \times \boxed{}^2$$

$$= \pi \times \boxed{}$$

$$= \boxed{} \text{ cm}^2$$

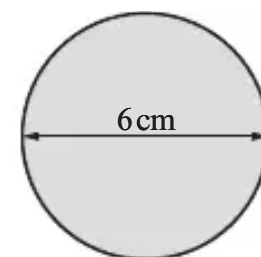
- 5 Copy and complete the working to work out the area of this circle.

Use $\pi = 3.142$. Round your answer correct to 2 decimal places (2 d.p.).

diameter, $d = 6 \text{ cm} \rightarrow$ radius, $r = 6 \div 2 = \boxed{} \text{ cm}$

$$A = \pi \times r^2 = \pi \times \boxed{}^2$$

$$= \pi \times \boxed{} = \boxed{} \text{ cm}^2$$



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7.1 Circumference and area of a circle

- 6 Copy and complete the working to work out the area of this semicircle.

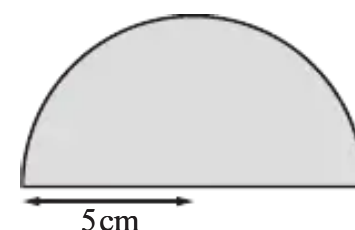
Use $\pi = 3.142$. Round your answer correct to 1 decimal place (1 d.p.).

area of semicircle = area of circle $\div 2$

Work out the area of the circle first:

$$A = \pi \times r^2 = \pi \times \boxed{}^2$$

$$= \pi \times \boxed{} = \boxed{} \text{ cm}^2$$



Tip

The area of a semicircle is half

area of semicircle = $\square \div 2 = \square \text{ cm}^2$

the area of a circle.

For the rest of the questions in this exercise, use the π button on your calculator.

Practice

7 Work out the area of each circle.

Round your answers correct to 3 significant figures (3 s.f.).

a radius = 2 cm

b radius = 3.75 m

c diameter = 28 cm

d diameter = 3.2 m

8 Dipti and Gabir work out the answer to this question.

Question Work out the area of a circle with diameter 2.4 cm.

This is what they write:

Dipti

Answer $\text{Area} = \pi r^2$
 $r^2 = 2.4^2 = 5.76$

$\text{Area} = \pi \times 5.76 = 18.0955$
 $\text{Area} = 18.1 \text{ cm}^2 \text{ (3 s.f.)}$

Gabir

Answer $\text{Area} = \pi d$
 $d = 2.4$

$\text{Area} = \pi \times 2.4 = 7.5398$
 $\text{Area} = 7.54 \text{ cm}^2 \text{ (3 s.f.)}$

- a Critique their solutions. Explain any mistakes they have made.
 b Write a full worked solution to show the correct way of answering the question.

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7 Shapes and measurements

9 For each circle, work out

i the area

ii the circumference.

Give your answers correct to one decimal place (1 d.p.).

a radius = 2.7 cm

b diameter = 45 mm

10 For each semicircle, work out

i the area

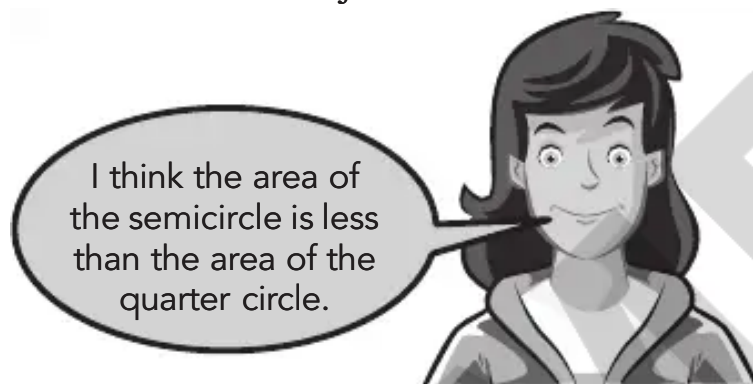
ii the perimeter.

Give your answers correct to one decimal place (1 d.p.).

a radius = 8.5 cm
c diameter = 32 cm

b radius = 24 mm
d diameter = 15 m

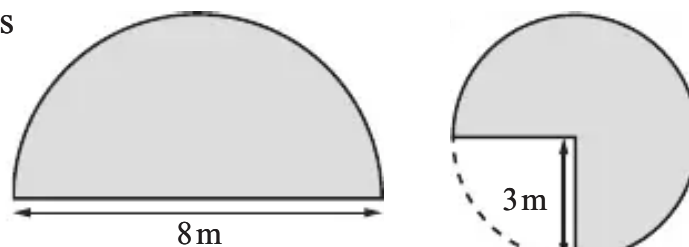
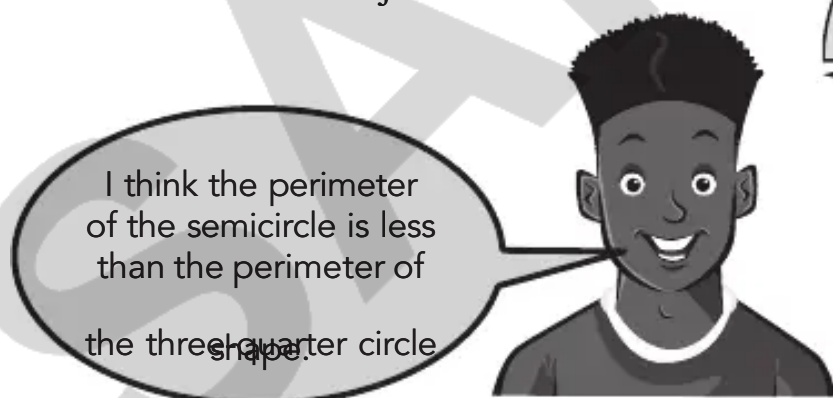
- 11 The diagram shows a semicircle and a quarter circle.
Sofia makes this conjecture:



Is she correct? Show working to support your answer.

- 12 The diagram shows a semicircle and three-quarters of a circle.

Marcus makes this conjecture:



Is Marcus correct? Show working to support your answer.

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7.1 Circumference and area of a circle

- 13 Here are six question cards and six answer cards.

A Work out A when $r = 4.76$	B Work out C when $d = 13.28$	C Work out A when $d = 19$
D Work out C when $r = 9.8$	E Work out d when $C = 35.47$	F Work out r when $A = 150.27$
i 284	ii 41.72	iii 6.92
iv 11.29	v 71.18	vi 61.6

- a ~~Do not use a calculator.~~ Using estimation, match each question card with the correct answer card.
 b Use a calculator to check you have matched the cards correctly.

Challenge

- 14 A circular coin has circumference 8.7 cm. Work out the radius of the coin.
 Give your answer correct to the nearest millimetre.
- 15 A circular floor has an area of 45.3 m². Work out the diameter of the floor.
 Give your answer correct to the nearest centimetre.
- 16 A circular badge has a circumference of 18.5 cm. Work out the area of the badge.
 Give your answer correct to the nearest square centimetre.
- 17 You can write the area and circumference of a circle in terms of π as shown:

When radius, $r = 5$ cm:
 area = $\pi r^2 = \pi \times 5^2 = 25\pi$ cm²
 circumference = $\pi d = \pi \times 2 \times 5 = 10\pi$ cm

Write the area and circumference of these circles in terms of π .

- a radius = 3 cm b radius = 7 m c diameter = 20 mm

- 18 Circle A has diameter 8 cm and circle B has diameter 16 cm.
- a Show that, for circle A, area = 16π cm² and circumference = 8π cm.
- b Work out the area and circumference of circle B in terms of π .
- c Copy and complete the table.

Circle A:Circle B	Radius (cm)	Circumference (cm)	Area (cm ²)
Ratio	4:8	8π : <input type="text"/>	16π : <input type="text"/>
Ratio in its simplest form	1:2	<input type="text"/> : <input type="text"/>	<input type="text"/> : <input type="text"/>

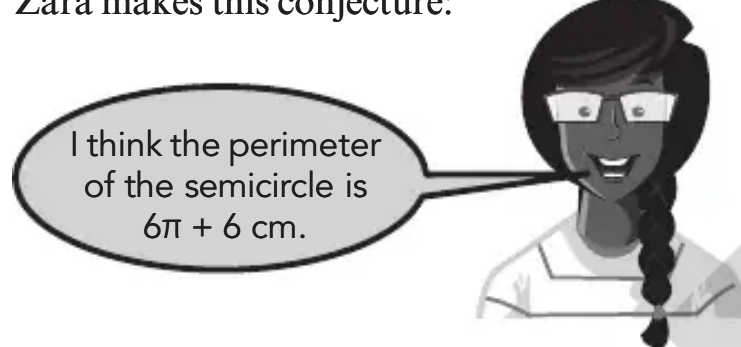
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7 Shapes and measurements

- d What do you notice about the ratios of the radius and circumference of circles A and B?
- e What do you notice about the ratios of the radius and area of circles A and B?
- f If the ratio of the radii of two circles is 1:3, what is the ratio of their **i** circumferences and **ii** areas?
 Explain how you worked out your answers.

- 19 The diagram shows a semicircle.

Zara makes this conjecture.



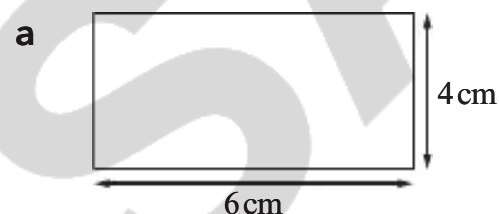
Is she correct? Show working to support your answer.

> 7.2 Areas of compound shapes

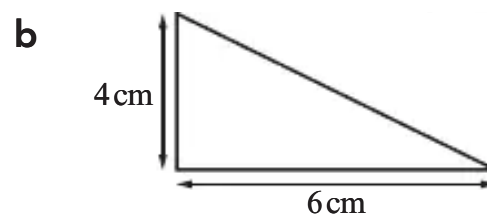
Exercise 7.2

Focus

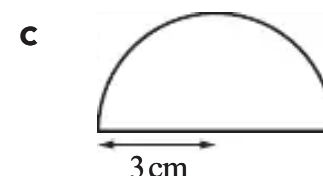
- 1 Copy and complete the workings to work out the area of each shape.
Give your answer to part c correct to two decimal places (2 d.p.).



$$\begin{aligned}\text{Area} &= \text{base} \times \text{height} \\ &= 6 \times 4 \\ &= \boxed{} \text{ cm}^2\end{aligned}$$



$$\begin{aligned}\text{Area} &= \frac{1}{2} \times \text{base} \times \text{height} \\ &= \frac{1}{2} \times 6 \times 4 \\ &= \boxed{} \text{ cm}^2\end{aligned}$$



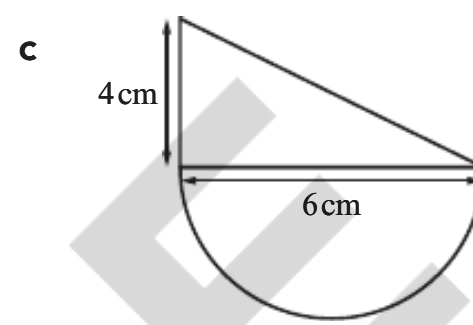
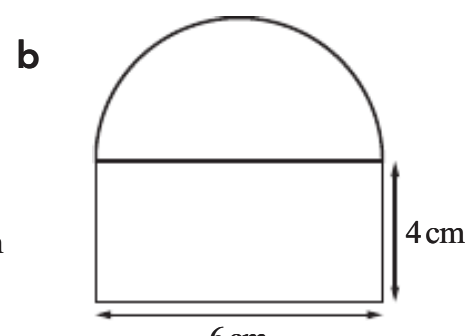
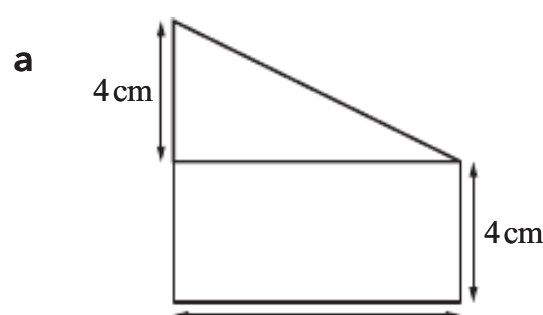
$$\begin{aligned}\text{Area} &= \frac{1}{2} \times \pi \times \text{radius}^2 \\ &= \frac{1}{2} \times \pi \times 3^2 \\ &= \boxed{} \text{ cm}^2\end{aligned}$$

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7.2 Areas of compound shapes

- 2 These compound shapes are made from the shapes in Question 1.
Use your answers to Question 1 to find the area of each compound shape.



6 cm

Area = semicircle +
triangle

Area = rectangle + triangle

$$= \boxed{} + \boxed{}$$

$$= \boxed{} \text{ cm}^2$$

Area = rectangle +
semicircle

$$= \boxed{} + \boxed{}$$

= cm²

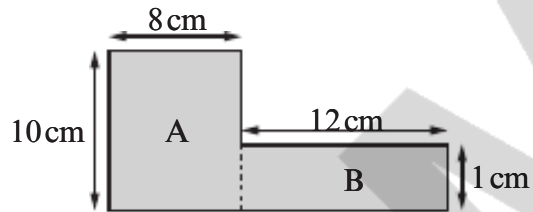
$$= \boxed{} + \boxed{}$$

$$= \boxed{} \text{ cm}^2$$

- 3** Copy and complete the workings to calculate the area of each compound shape.

Give your answers to parts **c** and **d** correct to two decimal places (2 d.p.).

a

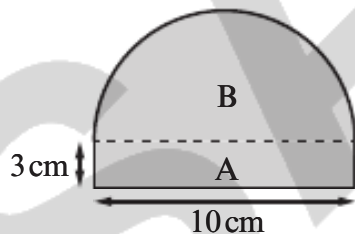


Area A = $l \times w = 8 \times \square = \square$

Area B = $l \times w = 12 \times \square = \square$

Total area = + = cm^2

C

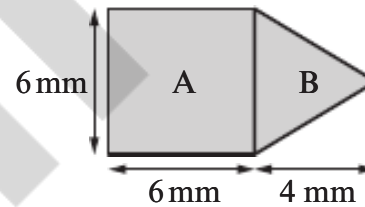


Area A = $l \times w = \square \times \square = \square$

$$\text{Area B} = \frac{1}{2} \pi r^2 = \frac{1}{2} \times \pi \times \boxed{}^2 = \boxed{}$$

Total area = + = cm^2

b

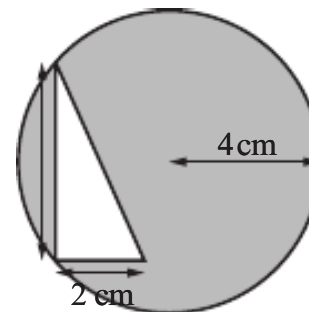


Area A = $l \times w = \square \times \square = \square$

$$\text{Area B} = \frac{1}{2} \times b \times h = \frac{1}{2} \times 6 \times \boxed{} = \boxed{}$$

Total area = + = mm²

d



$$\text{Area triangle} = \frac{1}{2} \times b \times h$$

$$= \frac{1}{2} \times \boxed{} \times \boxed{} = \boxed{}$$

Area circle = $\pi r^2 = \pi \times \boxed{}^2 = \boxed{}$

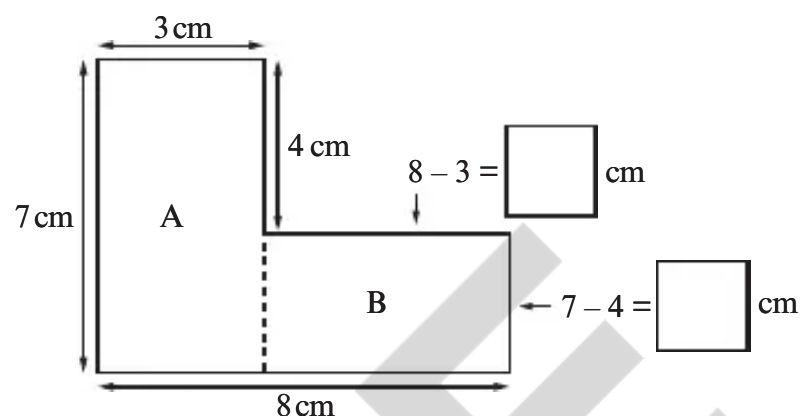
Shaded area = - = cm²

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7 Shapes and measurements

- 4 a** This compound shape is made from two rectangles, A and B. Work out the missing lengths.
- b** Copy and complete the workings to work out the area of the compound shape.



$$\text{Area A} = \text{base} \times \text{height}$$

Area B = base \times height

$$= 3 \times \square$$

$$= \square \text{ cm}^2$$

$$= 5 \times \square$$

$$= \square \text{ cm}^2$$

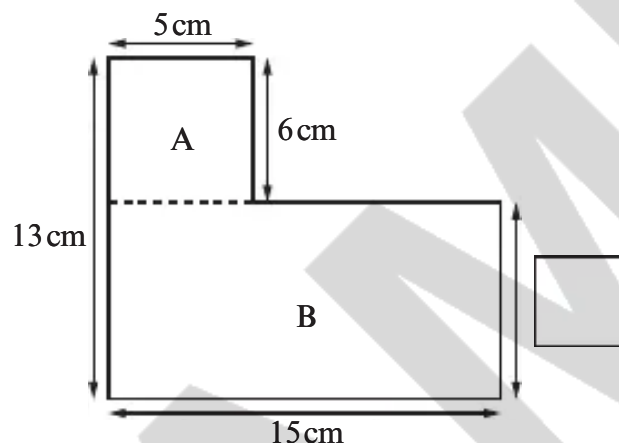
$$\text{Total area} = \text{Area A} + \text{Area B} = \square + \square = \square \text{ cm}^2$$

5 For each of these compound shapes, work out

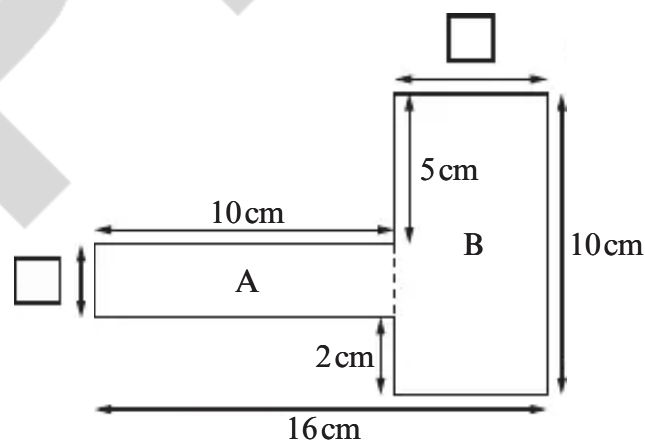
i the missing lengths

ii the area of the shape.

a



b

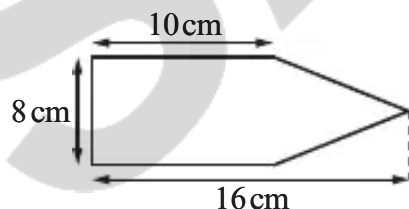


Practice

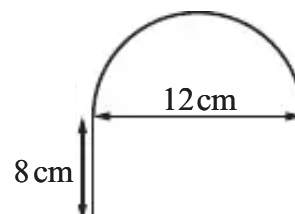
6 Work out the area of each compound shape.

Give your answer to part b correct to two decimal places (2 d.p.).

a



b



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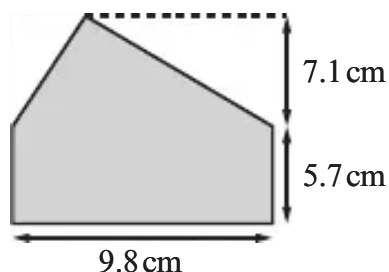
7.2 Areas of compound shapes

7 For each of these compound shapes, work out

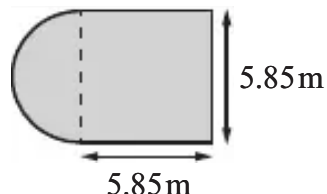
i an estimate of the area of the shape

ii the area of the shape correct to one decimal place (1 d.p.).

a

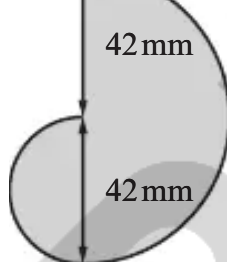
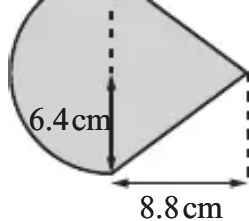


b



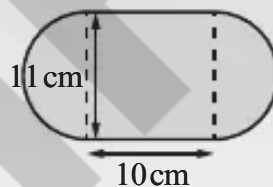
Tip

Remember: to work out an estimate, round all the numbers to one significant figure.



- 8 This is part of Seb's homework.

Question A compound shape is made of two semicircles and a rectangle. The rectangle has a side length of 10 cm and a height of 11 cm as shown.

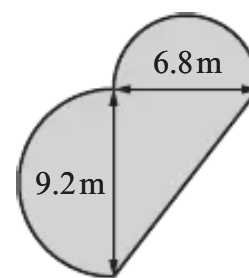


Work out the area of the shape correct to 3 s.f.

Answer Area of rectangle = $10 \times 11 = 110$
 The two semicircles make one circle, so area of circle = $\pi r^2 = \pi \times 11^2 = 380.1327...$
 Total area = $110 + 380 = 490 \text{ cm}^2$ (3 s.f.)

- 9 Is Seb's method correct? Explain your answer. Show your working. Chatri works out the area of this compound shape to be 82 cm^2 (2 s.f.).

Is Chatri correct? Explain your answer. Show all your working.



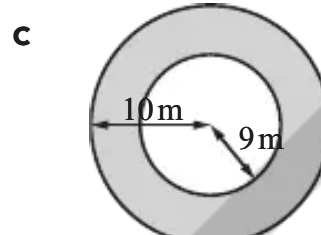
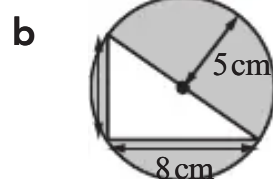
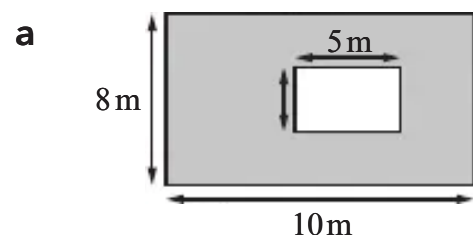
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7 Shapes and measurements

- 10 Work out the area of each shaded shape.

Give your answers to parts **b** and **c** correct to two decimal places (2 d.p.).

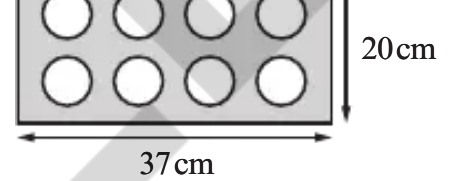


Challenge

- 11 The diagram shows a rectangular piece of pastry with eight circles cut out.

The diameter of each circle is 8 cm.

What is the area of the pastry that is left? Give your answer correct to three significant figures (3 s.f.).



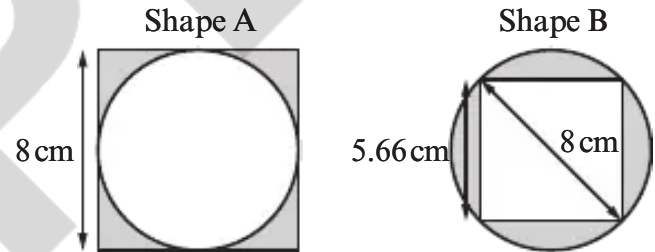
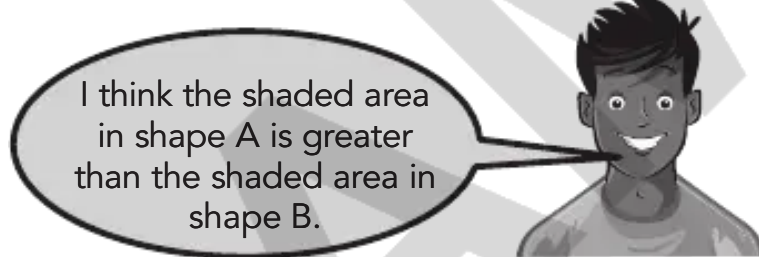
- 12 Arun draws these two shapes.

In shape A, the side length of the square is the diameter of the circle.

In shape B, the diagonal of the square is the

diameter of the circle.

Arun makes this conjecture:

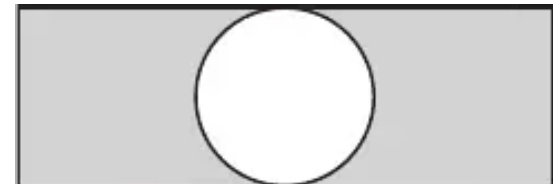


What do you think? Explain your answer. Show your working.

- 13 The diagram shows a circle inside a rectangle.

The height of the rectangle is the diameter of the circle.

The length of the rectangle is three times the height of the rectangle.



- Show that when the radius of the circle is 2 cm, you can write the shaded area as $4(12 - \pi)\text{cm}^2$.
- Work out an expression for the shaded area when the radius is
 - 1 cm
 - 3 cm
 - 5 cm
 - 10 cm
- What do you notice about your answers to parts **a** and **b**?
- Write a general expression, using algebra, for the shaded area when the radius is r .

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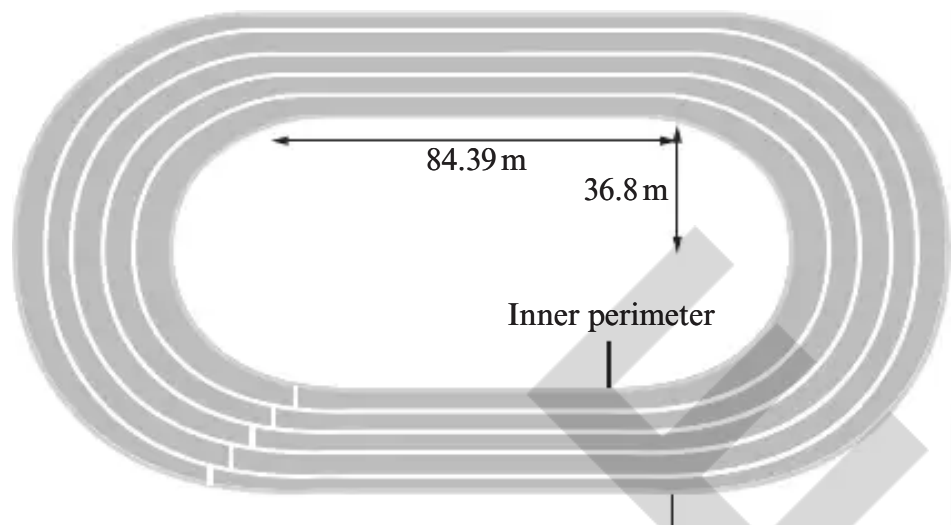
7.2 Areas of compound shapes

- 14 The diagram shows an athletics track. The radius of the inner semicircle at each end is 36.8 m.

The length of the straight section is 84.39 m.

- Work out the length of the inner perimeter of the track. Give your answer correct to the nearest metre.

- Work out the total area



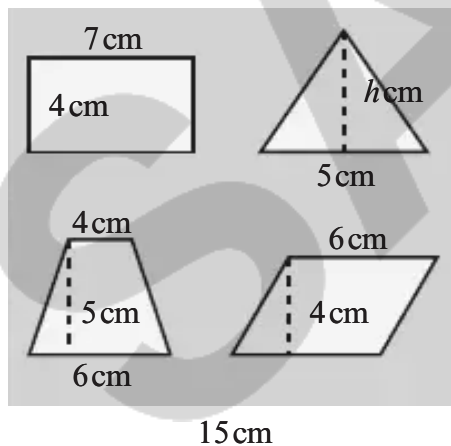
enclosed by the inner
perimeter (shown in white).

Outer perimeter

Give your answer correct to the nearest square metre.

- c The width of each lane is 1.22 m. There are eight lanes.
Work out the radius of the outer semicircle at each end of the track.
- d Work out the length of the outer perimeter of the track.
Give your answer correct to the nearest metre.
- e Work out the total area enclosed by the outer perimeter (white area plus track).
Give your answer correct to the nearest square metre.
- f Work out the area of the actual track.
Give your answer correct to the nearest square metre.

15 The diagram shows a shapes stencil.



The stencil is made from a square of plastic, with the four shapes cut out.

The shaded area is 126 cm^2 .

What is the height, h , of the triangle?

Tip

Remember:

The formula for the area of a trapezium is:

$$\text{area} = \frac{1}{2}(a + b) \times h$$

The formula for the area of a parallelogram is:

$$\text{area} = \text{base} \times \text{perpendicular height}$$

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7 Shapes and measurements

> 7.3 Large and small units

This table shows some of the **prefixes** you can use when you measure very large or very small lengths, capacities and masses.

Prefix	Letter	Multiply by	Multiply by
tera	T	1 000 000 000 000	10^{12}
giga	G	1 000 000 000	10^9
mega	M	1 000 000	10^6
kilo	k	1 000	10^3
hecto	h	100	10^2

Key words

prefix
tonne

centi	c	0.01	10^{-2}
milli	m	0.001	10^{-3}
micro	μ	0.000 001	10^{-6}
nano	n	0.000 000 001	10^{-9}

Exercise 7.3

Focus

- 1 Copy and complete these conversions. The first one has been done for you.

- a 1 hectometre = 100 metres
b 1 kilogram = grams
c 1 megatonne = tonnes
d 1 giganlitre = litres

Tip

Use the table of prefixes in the introduction.

- 2 Copy and complete these conversions. The first one has been done for you.

- a 1 centimetre = 0.01 metres OR 1 metre = 100 centimetres
b 1 milligram = grams OR 1 gram = milligrams
c 1 microlitre = litres OR 1 litre = microlitres
d 1 nanometre = metres OR 1 metre = nanometres

- 3 a Write these capacities in order of size, starting with the smallest.

3 centilitres

3 litres

3 teralitres

3 millilitres

3 nanolitres

- b Underneath each of the capacities in part a, write the capacity using only the correct letters for the units, not words. For example, underneath 3 centilitres, write 3 cL.

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7.3 Large and small units

- 4 a Write these masses in order of size, starting with the smallest.

9 gigagrams

9 grams

9 milligrams

9 kilograms

9 micrograms

- b Underneath each of the masses in part a, write the mass using only the correct letters for the units, not words. For example, underneath 9 gigagrams, write 9 Gg.

Practice

- 5 Copy and complete these descriptions. Use all the words and letters in the box.

length	one thousandth	μg	mass	one millionth	mm
metres	one thousand	g	m	one million	grams

- a** A millimetre is a very small measure of It is represented by the letters 1 millimetre = 0.001 which is the same as $1\text{ mm} = 1 \times 10^{-3}$ You can also say that there are millimetres in a metre or that 1 millimetre is of a metre.
- b** A microgram is a very small measure of It is represented by the letters 1 microgram = 0.000 001 which is the same as $1\text{ }\mu\text{g} = 1 \times 10^{-6}$ You can also say that there are micrograms in a gram or that 1 microgram is of a gram.

6 Copy and complete these descriptions. Use all the words, letters and numbers in the box.

km	one thousandth	large	Mt	metres	one millionth
tonnes	mass	3	one thousand	6	megatonne

- a** A kilometre is a very measure of length. It is represented by the letters
1 kilometre = 1000 which is the same as $1\text{ km} = 1 \times 10^{\square}$ metres.
You can also say that there are metres in a kilometre or that 1 metre is of a kilometre.

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7 Shapes and measurements

- b** A megatonne is a very large measure of It is represented by the letters
1 = 1 000 000 tonnes which is the same as
 $1\text{ Mt} = 1 \times 10^{\square}\text{ t}$.
You can also say that there are one million in a megatonne or that 1 tonne is of a megatonne.

7 Copy and complete these conversions.

- a** 17.2 km to m $\xrightarrow{\quad}$ $1\text{ km} = 1000\text{ m}$, so $17.2\text{ km} =$
 $17.2 \times 1000 = \square\text{ m}$

Tip

Use the table of prefixes in the

b 0.9 hL to l → 1 hL = 100 L, so 0.9 hL = 0.9 × 100 = L

c 1.5 Gg to g → 1 Gg = g, so 1.5 Gg = 1.5 ×
= g

8 Copy and complete these conversions.

a 760 cm to m → 100 cm = 1 m, so 760 cm = 760 ÷ 100 = m

b 43 000 mL to L → 1000 mL = 1 L, so 43 000 mL = 43 000 ÷ 1000 = L

c 900 000 µg to g → µg = 1 g,
so 900 000 µg = 900 000 ÷ = g

9 The table shows the approximate distances from the Sun to some planets.
Copy and complete the table.

From the Sun to	Distance in ...	Distance in ...
Venus	47 900 000 m	47.9 Mm
Earth	108 000 000 m	<input type="text"/> Mm
Jupiter	228 000 000 m	<input type="text"/> Gm
Uranus	1 400 000 000 m	<input type="text"/> Gm
Neptune	2 900 000 000 m	<input type="text"/> Gm

10 Cards A to E show the approximate length, in metres, of some very small objects.

A Dust mite 0.0002 m	B Bacterium 0.000 002 m	C Virus 0.000 000 1 m	D Animal cell 0.000 02 m	E Plant cell 0.000 1 m
--------------------------------	-----------------------------------	---------------------------------	------------------------------------	----------------------------------

Cards i to v show the lengths of the objects measured in millimetres,
micrometres or nanometres.

i 100 nm	ii 20 µm	iii 200 µm	iv 100 µm	v 2 µm
-----------------	-----------------	-------------------	------------------	---------------

Match each card A to E with the correct card i to v.



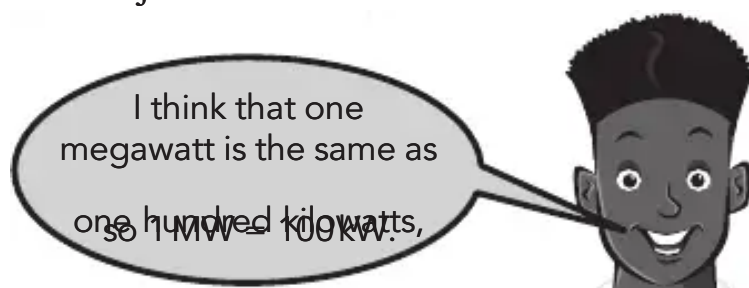
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7.3 Large and small units

Challenge

11 A watt (W) is a measure of electrical power.

Marcus finds out that a power station near his house produced 630 megawatts of electricity last year. Marcus makes this conjecture:





- a Is Marcus’s conjecture correct? Show working to support your decision.
- b Copy and complete this conversion:
 $630\text{ MW} = \boxed{}\text{ kW} = \boxed{}\text{ W}$

12 The letters ly are used to represent a light year.

15

$1\text{ ly} \approx 9.46 \times 10^{15}\text{ m}$

The table shows the approximate distance, in light years, of four stars from the Earth.

Copy and complete the table. Round your answers correct to three significant figures.

The first one has been done for you.

Name of star	Distance in ly	Distance in m
Wolf 359	7.78	7.36×10^{16}
Ross 154	9.68	
YZ Ceti	12.13	
Gliese 832	16.08	

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7 Shapes and measurements



- 13 a These cards show different computer file sizes. Write the file sizes in order, starting with the smallest.

A 42.5MB	B 936KB	C 6.3TB	D 12KB	E 1.14GB
----------	---------	---------	--------	----------

- b The table shows the number of photos, of different sizes, that can be stored on a 1 GB memory card.

Photo size (MB)	1.2	1.5	1.8	2.4	3.0	4.8	6.6
Number of photos	715	572	476	357	286	178	130

- i Alun takes photos of size 4.8MB. Show that he can store 2848 photos on a 16 GB memory card.

- ii How many **more** photos of size 1.5 MB can be stored on a 64 GB memory card than photos of size 6.6 MB?
- iii Erin takes photos of size 3.6 MB. Approximately how many photos can she store on a 1 GB memory card? Explain how you worked out your answer.
- iv Sue has a 32 GB memory card. She wants to store about 13 000 photos on the memory card. What photo size do you suggest Sue uses? Justify your answer. Show all your working.

- 14** A supertanker has a mass of 509.5 Mt when full and a mass of 67.6 Mt when empty.
When the supertanker is full, it holds 3 166 353 barrels of oil.
Work out the mass, in kilograms, of one barrel of oil. Give your answer to the nearest whole number.

Tip

A supertanker is a ship that carries oil from one country to another country.



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8

Fractions

> 8.1 Fractions and recurring decimals

Exercise 8.1

Focus

equivalent
decimal
recurring decimal
terminating
decimal

- 1 a Copy and complete.

$\frac{1}{8} = 0.125$ which is a **terminating decimal**

$\frac{2}{8} = 2 \times \frac{1}{8} = 2 \times 0.125 = \square$ which is a decimal

$\frac{3}{8} = 3 \times \frac{1}{8} = 3 \times 0.125 = \square$ which is a decimal

$\frac{5}{8} = 5 \times \frac{1}{8} = 5 \times 0.125 = \square$ which is a decimal

- b Copy and complete.

$\frac{1}{20} = 0.05$ which is a terminating decimal

$\frac{3}{20} = 3 \times \frac{1}{20} = 3 \times 0.05 = \square$ which is a decimal

$\frac{5}{20} = 5 \times \frac{1}{20} = 5 \times 0.05 = \square$ which is a decimal

$\frac{9}{20} = 9 \times \frac{1}{20} = 9 \times 0.05 = \square$ which is a decimal

- 2 a Work out the **equivalent decimal** of $\frac{1}{6}$

- b Is $\frac{1}{6}$ a terminating or **recurring decimal**?

- c Use your answers to parts **a** and **b** to write the decimal equivalents of these fractions. Write if each decimal is terminating or recurring.

i $\frac{2}{6}$

ii $\frac{3}{6}$

iii $\frac{4}{6}$

iv $\frac{5}{6}$

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8 Fractions



- 3 a Work out the decimal equivalent of $\frac{1}{25}$
- b Is $\frac{1}{25}$ a terminating or recurring decimal?
- c Use your answers to parts **a** and **b** to write the decimal equivalents of these fractions. Write if each fraction is terminating or recurring.
- i $\frac{2}{25}$ ii $\frac{5}{25}$ iii $\frac{11}{25}$ iv $\frac{20}{25}$
- d Look at your answers to parts **c ii** and **c iv**. Did you write these fractions in their simplest form before you changed them into decimals? If you did, explain why. If you didn't, do you think it would have been easier if you had?



- 4 Here are five fraction cards.

A $\frac{1}{4}$	B $\frac{1}{5}$	C $\frac{1}{8}$	D $\frac{1}{10}$	E $\frac{1}{16}$
------------------------	------------------------	------------------------	-------------------------	-------------------------

- a** Without doing any calculations, answer this question.
Are these fractions terminating or recurring decimals?
Explain how you know.
- b** All the numerators are changed from 1 to 2, so the cards now look like this:
- | | | | | |
|------------------------|------------------------|------------------------|-------------------------|-------------------------|
| A $\frac{2}{4}$ | B $\frac{2}{5}$ | C $\frac{2}{8}$ | D $\frac{2}{10}$ | E $\frac{2}{16}$ |
|------------------------|------------------------|------------------------|-------------------------|-------------------------|
- Are all the fractions still terminating decimals?
Explain your answer.
- c** When all the numerators in part **b** are changed from 2 to 3, are all the fractions still terminating decimals?
Explain your answer.

Practice

- 5** Decide if these statements about proper fractions are ‘Always true’, ‘Sometimes true’ or ‘Never true’. Justify your answers.
- a** A fraction with a denominator of 14 is a recurring decimal.
- b** A fraction with a denominator which is a multiple of 5 is a recurring decimal.
- c** A unit fraction with a denominator which is a multiple of 15 is a terminating decimal.
- d** A fraction with a denominator which is a power of 3 is a recurring decimal.

Tip

The numbers which are powers of 3 are $3^1 = 3$, $3^2 = 9$, $3^3 = 27$, etc.

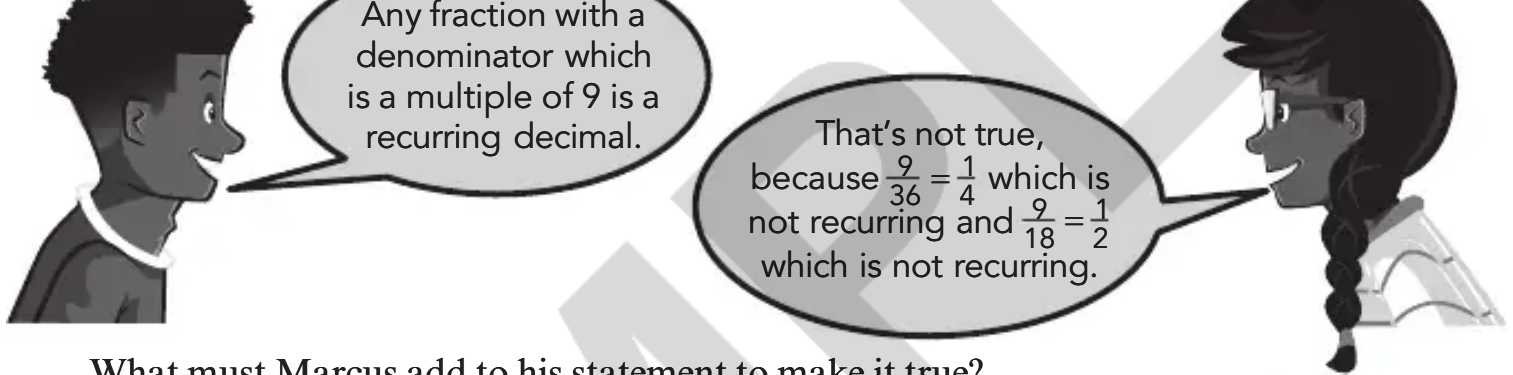
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8.1 Fractions and recurring decimals

- 6** Here are five fraction cards.

A $\frac{5}{9}$	B $\frac{3}{18}$	C $\frac{11}{27}$	D $\frac{6}{36}$	E $\frac{13}{45}$
------------------------	-------------------------	--------------------------	-------------------------	--------------------------

- a** Without doing any calculations, answer this question.
Do you think these fractions are terminating or recurring decimals? Explain why.
- b** Which two fractions are different from the others?
Explain this difference.
Does this change your answer to part **a**? Explain why.
- c** Read what Marcus and Zara say.



What must Marcus add to his statement to make it true?

- 7 Write each number of minutes as a fraction of an hour. Decide if each fraction of an hour is a terminating or recurring decimal.

- a 15 minutes b 48 minutes c 32 minutes
d 12 minutes e 10 minutes f 42 minutes

- 8 Without using a calculator, decide if these fractions are terminating or recurring decimals.

- a $\frac{19}{6}$ b $\frac{15}{12}$ c $\frac{38}{7}$ d $\frac{35}{14}$

Tip

Think about how many minutes there are in an hour.

Tip

Change the improper fractions to mixed numbers first.

Challenge

- 9 The table shows the number of days off work due to illness that six friends take over a six-week period. There are 30 working days in a six-week period.

Number of days off work due to illness					
Abi	8	Bim	5	Caz	3
Dave	6	Enid	2	Fin	9

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8 Fractions

- a Sort the friends into two groups according to the number of days they take off work, as a fraction of the number of working days in the six-week period. Explain the criteria you used to group them.
- b Sort the friends into two different groups according to the number of days they take off work, as a fraction of the number of working days in the six-week period. Explain the criteria you used to group them this time.

- 10 Here are eight fraction cards.



- a In the following calculations, **R** represents one of the eight fraction cards that is a recurring decimal, and **T** represents

fraction cards that is a recurring decimal, and **T** represents one of the eight fraction cards that is a terminating decimal.

Using only the cards shown, work out which two fractions you can add to get either a recurring (R) or terminating (T) decimal answer. You can use the same card more than once.

- i

R + **R** = R
- ii

T + **R** = R
- iii

R + **R** = T
- iv

T + **T** = T

- b

Show how you can answer part a again, but this time using each card once only.
- c

Do you think it is possible, using any terminating fractions, to get **T** + **T** = **R**?

Use specialising to justify your answer.

> 8.2 Fractions and the correct order of operations

Exercise 8.2

Focus

- 1 Copy and complete these calculations.

a

$2\frac{1}{8} + \left(1\frac{1}{2} - \frac{1}{4}\right)$

Brackets:

$1\frac{1}{2} - \frac{1}{4} = 1\frac{\square}{4} - \frac{\square}{4} = 1\frac{\square}{4}$

Addition:

$2\frac{1}{8} + 1\frac{\square}{4} = 2\frac{1}{8} + 1\frac{\square}{8} = 3\frac{\square}{8}$

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8.2 Fractions and the correct order of operations

b

$3 + \frac{2}{3} \times \frac{4}{5}$

Multiplication:

$\frac{2}{3} \times \frac{4}{5} = \frac{2 \times 4}{3 \times 5} = \frac{\square}{\square}$

Addition:

$3 + \frac{\square}{\square} = 3\frac{\square}{\square}$

c

$2^2 \div \frac{3}{5} - 1\frac{5}{6}$

Indices:

$2^2 = 4$

Division:

$4 \div \frac{3}{5} = 4 \times \frac{5}{3} = \frac{\square}{3}$

Subtraction:

$\frac{\square}{3} - 1\frac{5}{6} = \frac{\square}{6} - \frac{11}{6} = \frac{\square}{6} = \frac{\square}{6}$

- 2 Work out these calculations. Write each answer as a mixed number

in its simplest form. Show all the steps in your working.

a $4\frac{3}{8} + \frac{1}{2} \times \frac{3}{4}$

b $\frac{3}{5} \times \frac{1}{2} + 2\frac{1}{10}$

c $5\frac{5}{8} - \left(2\frac{1}{2} + \frac{3}{8}\right)$

d $\frac{5}{8} \div \frac{15}{16} + 4\frac{1}{3}$

3 Match each calculation with the correct answer. Show all your working.

A $5\frac{1}{4} + \frac{1}{2} \times \frac{5}{6}$

B $8\frac{2}{3} - \left(4\frac{3}{4} - 1\frac{1}{2}\right)$

C $\frac{11}{12} \times \left(3^2 \div \frac{3}{2}\right)$

i $5\frac{1}{2}$

ii $5\frac{2}{3}$

iii $5\frac{5}{12}$

Practice

4 For each calculation, work out

i an estimate

ii the accurate answer.

Show all the steps in your working.

a $10 - \left(1\frac{1}{6} + 2\frac{7}{12}\right)$

b $4\frac{2}{9} + \left(7\frac{2}{3} - \frac{1}{2}\right)$

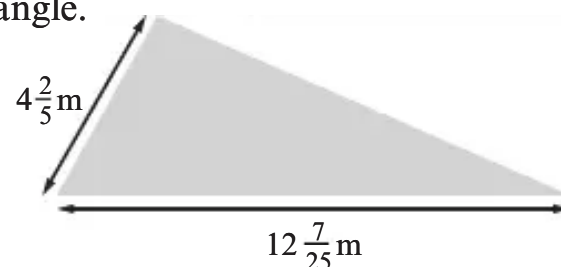
c $6\frac{7}{8} + 2\frac{1}{4} \times 15$

d $18\frac{1}{14} - \frac{6}{7} \times \frac{5}{2}$

5 The diagram shows the lengths of two of the sides of a triangle.

The triangle has a perimeter of $25\frac{49}{50}$ m.

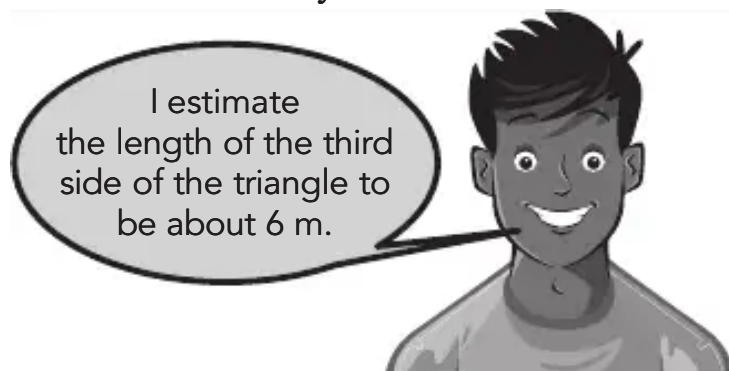
a Write the calculation you must do to work out the length of the third side of the triangle.



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8 Fractions

b Read what Arun says.



What do you think of Arun's estimate? Explain your answer.

c Work out the length of the third side of the triangle. Was your answer to part **b** correct? Explain your answer.

6 Shania has a mass of $57\frac{2}{3}$ kg. Kiera's mass is $2\frac{1}{3}$ kg more than

- 6 Shania has a mass of $57\frac{1}{5}$ kg. Kiera's mass is $2\frac{3}{4}$ kg more than Shania's mass.
The total mass of Shania, Kiera and Lara is $173\frac{3}{4}$ kg. Work out Lara's mass.

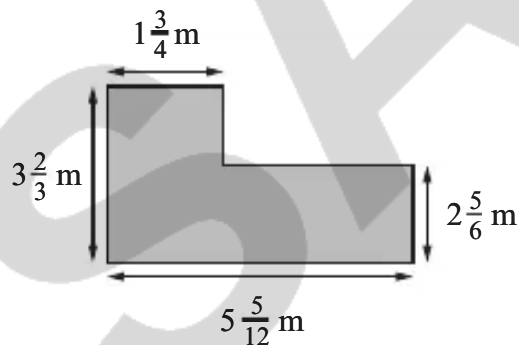
- 7 Copy and complete the workings to calculate the answer to $\frac{2}{3} \div \frac{3}{7} + 6\frac{1}{2} \times 7$

Division: $\frac{2}{3} \div \frac{3}{7} = \frac{2}{3} \times \frac{\boxed{}}{\boxed{}} = \frac{\boxed{}}{\boxed{}}$

Multiplication: $6\frac{1}{2} \times 7 = \frac{\boxed{}}{2} \times 7 = \frac{\boxed{}}{2}$

Addition: $\frac{\boxed{}}{9} + \frac{\boxed{}}{2} = \frac{\boxed{}}{18} + \frac{\boxed{}}{18} = \frac{\boxed{}}{18}$

- 8 Work out the area of this compound shape. Show all your working.



Challenge

- 9 Work out the answers to these calculations.

a $\left(3\frac{1}{2}\right)^2 + 3\frac{1}{2}$

b $16 \times 2\frac{1}{4} - \left(\frac{3}{4}\right)^2$

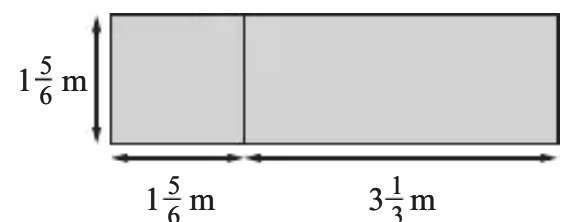
c $10\frac{4}{5} + 81 \times \left(3\frac{1}{3}\right)^2$

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8.3 Multiplying fractions

- 10 The diagram shows a compound shape made of a square joined to a rectangle.

- a Write the calculation you must do to work out the total area of the shape.
b Work out the area of the shape.

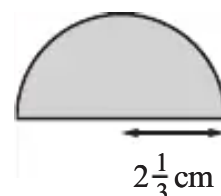


- 11 The diagram shows a semicircle.

Work out

- a the area of the semicircle
b the perimeter of the semicircle.

Use $\pi = \frac{22}{7}$



> 8.3 Multiplying fractions

When you multiply an integer by a fraction, it is often easier to **cancel common factors** first. Look at the steps in this example:

Calculate $\frac{3}{4} \times 20$

Step 1 Look at the denominator of the fraction. In this case it is 4.

Step 2 4 goes into 20 five times, so rewrite 20 as 4×5 . $\frac{3}{4} \times 4 \times 5$

Step 3 The $\div 4$ and $\times 4$ cancel each other out. $\frac{3}{\cancel{4}} \times \cancel{4} \times 5$

Step 4 Work out the remaining multiplication. $3 \times 5 = 15$

Sometimes you cannot divide the denominator into the integer, but you can still divide by a common factor. Look at this example:

Calculate $\frac{3}{4} \times 10$

Step 1 4 will not divide exactly into 10, but 2 goes into both 4 and 10.

Step 2 Rewrite 4 as 2×2 and rewrite 10 as 2×5 . $\frac{3}{2 \times 2} \times 2 \times 5$

Step 3 One $\div 2$ and the $\times 2$ cancel each other out. $\frac{3}{2 \times \cancel{2}} \times \cancel{2} \times 5$

Step 4 Work out the remaining multiplication. $\frac{3 \times 5}{2} = \frac{15}{2}$

Step 5 Write your answer as a mixed number. $\frac{15}{2} = 7\frac{1}{2}$

Key words

cancelling
common factors

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8 Fractions

Exercise 8.3

Focus

1 Copy and complete the working in these multiplications by cancelling common factors first.

a $\frac{2}{3} \times 12 = \frac{2}{3} \times 3 \times 4 = \square \times \square = \square$

b $\frac{3}{5} \times 20 = \frac{3}{5} \times \square \times \square = \square \times \square = \square$

c $\frac{5}{6} \times 18 = \frac{5}{6} \times \square \times \square = \square \times \square = \square$

d $\frac{4}{9} \times 27 = \frac{4}{9} \times \square \times \square = \square \times \square = \square$

Tip

In **a**, 3 is the common factor, so cross out the 3s.

In **b**, rewrite 20 as 5×4 , then cancel the common factor.

e $\frac{3}{4} \times 32 = \frac{3}{4} \times \square \times \square = \square \times \square = \square$
 f $\frac{5}{8} \times 48 = \frac{5}{8} \times \square \times \square = \square \times \square = \square$
 g $\frac{4}{7} \times 35 = \frac{4}{7} \times \square \times \square = \square \times \square = \square$

In c, rewrite 18 as $6 \times \square$.

In d, rewrite 27 as $\square \times \square$.

2 Work out these multiplications. Cancel common factors first.

a $\frac{2}{5} \times 15$ b $\frac{3}{4} \times 24$ c $\frac{7}{8} \times 32$

3 Copy and complete the working in these multiplications by cancelling common factors first.

a $\frac{1}{8} \times 20 = \frac{1}{4 \times 2} \times 4 \times 5 = \frac{\square \times \square}{\square} = \frac{\square}{2} = \square \frac{\square}{2}$
 b $\frac{3}{10} \times 25 = \frac{3}{\square \times \square} \times \square \times \square = \frac{\square \times \square}{\square} = \frac{\square}{2} = \square \frac{\square}{2}$
 c $\frac{3}{4} \times 14 = \frac{3}{\square \times \square} \times \square \times \square = \frac{\square \times \square}{\square} = \frac{\square}{\square} = \square \frac{\square}{\square}$
 d $\frac{5}{9} \times 24 = \frac{5}{\square \times \square} \times \square \times \square = \frac{\square \times \square}{\square} = \frac{\square}{\square} = \square \frac{\square}{\square}$

Tip

In a, 4 is a common factor, so cross out the 4s.

In b, rewrite 10 as 5×2 and rewrite 25 as 5×5 .

4 Work out these multiplications. Cancel common factors first.

a $\frac{1}{4} \times 18$ b $\frac{3}{8} \times 10$ c $\frac{7}{12} \times 16$

8.3 Multiplying fractions

Practice

5 Work out these multiplications. Cancel common factors first.

In parts f to j, write each answer as a mixed number in its simplest form.

a $\frac{3}{5} \times 15$ b $\frac{3}{4} \times 16$ c $\frac{3}{5} \times 25$ d $\frac{3}{7} \times 77$ e $\frac{3}{13} \times 130$
 f $\frac{3}{8} \times 18$ g $\frac{4}{15} \times 35$ h $\frac{5}{12} \times 8$ i $\frac{6}{25} \times 55$ j $\frac{7}{20} \times 32$

6 Work out these multiplications. Cancel common factors before multiplying when possible.

Write each answer in its simplest form.

a $\frac{3}{5} \times \frac{6}{7}$ b $\frac{4}{5} \times \frac{7}{12}$ c $\frac{5}{7} \times \frac{7}{8}$ d $\frac{19}{20} \times \frac{5}{7}$ e $\frac{3}{4} \times \frac{7}{10}$

f $\frac{3}{4} \times \frac{12}{13}$ g $\frac{6}{21} \times \frac{7}{18}$ h $\frac{3}{8} \times \frac{8}{15}$ i $\frac{21}{22} \times \frac{4}{6}$ j $\frac{8}{15} \times \frac{5}{24}$

- 7 a The guests at a party eat $\frac{3}{4}$ of the cakes. Yasmina eats $\frac{1}{4}$ of what is left.
What fraction of the cakes does Yasmina eat?
- b The guests at another party eat $\frac{9}{10}$ of a salad. Marie eats $\frac{2}{3}$ of what is left.
What fraction of the salad does Marie eat?

- 8 Sarah uses the formula $C = \pi d$ to work out the circumference of a circle. She uses $\pi = \frac{22}{7}$.
Sarah thinks 22 cm is the smallest whole number value for d so that the circumference is greater than 64 cm. Is Sarah correct? Explain your answer. Show all your working.

- 9 For each of these multiplications, work out
- i an estimate ii the accurate answer.
- Cancel common factors before multiplying when possible.
Write each answer as a mixed number in its simplest form.

a $2\frac{1}{4} \times 1\frac{2}{5}$ b $1\frac{1}{4} \times 4\frac{1}{5}$ c $2\frac{1}{7} \times 2\frac{1}{6}$

d $5\frac{1}{2} \times 2\frac{4}{33}$ e $2\frac{1}{5} \times 1\frac{1}{5}$ f $8\frac{1}{3} \times 2\frac{7}{10}$

Tip

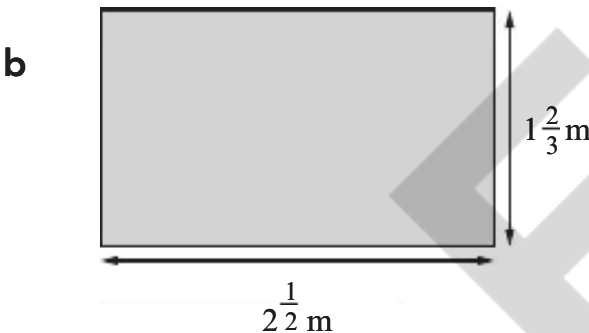
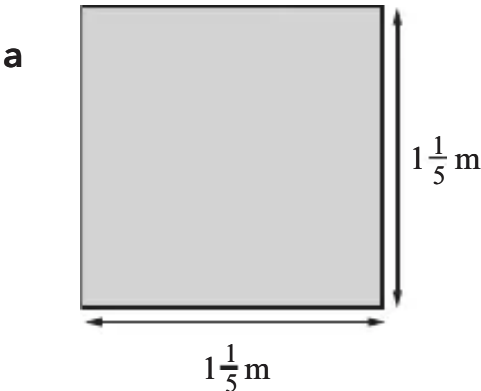
Estimate the answer by rounding one of the fractions to the nearest half and rounding the other fraction to the nearest whole number.

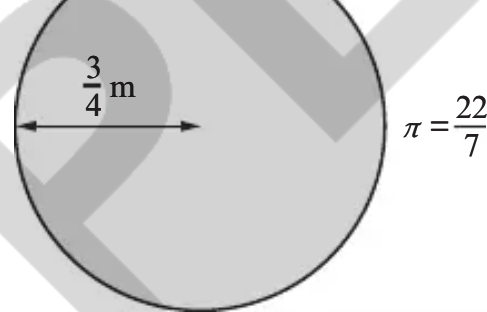
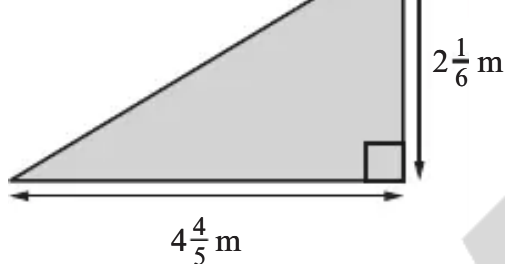
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8 Fractions

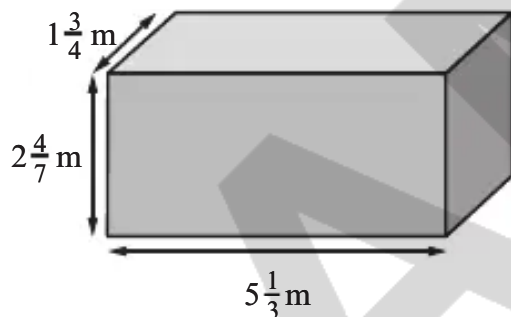
Challenge

- 10 Work out the area of each shape. Give each answer as a mixed number in its simplest form.

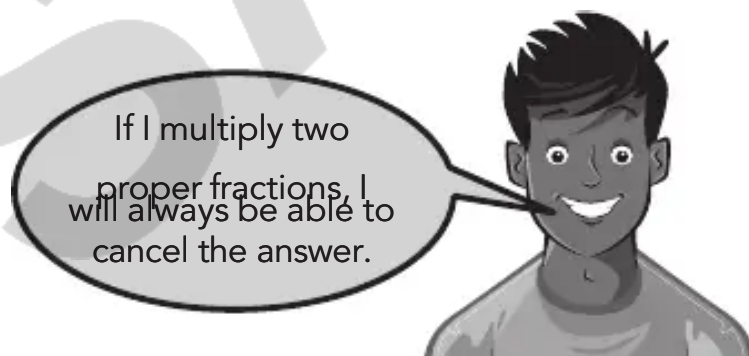




- 11 Work out the volume of this cuboid.



- 12 a Read what Arun says.



Tip

You can specialise by testing examples such as $\frac{2}{3} \times \frac{1}{2}$, $\frac{3}{4} \times \frac{8}{9}$ and $\frac{5}{6} \times \frac{5}{7}$

Use specialising to show that Arun is incorrect.

- b How can you tell, by looking at the proper fractions you are going to multiply, whether you will or will not be able to cancel the answer?

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8.4 Dividing fractions

- 13 Here is a calculation, four fractions and two mixed numbers.

$$\left(\frac{\square}{\square}\right)^2 + \square \frac{\square}{\square} \times \frac{\square}{\square} = 2\frac{14}{45}$$

$\frac{4}{5}$

$\frac{2}{3}$

$\frac{7}{8}$

$\frac{4}{9}$

$1\frac{3}{4}$

$2\frac{1}{3}$

Work out which fractions and mixed numbers go in the calculation to give the answer shown.



When you divide by a fraction, remember to turn the fraction upside down and multiply instead. For example, the division $12 \div \frac{2}{3}$ becomes $12 \times \frac{3}{2}$

Exercise 8.4

Focus

- 1 Match each division with the correct multiplication. One has been done for you: **A** and **ii**.

A $12 \div \frac{3}{4}$	B $12 \div \frac{3}{5}$	C $12 \div \frac{1}{4}$	D $12 \div \frac{5}{3}$	E $12 \div \frac{4}{3}$
i $12 \times \frac{4}{1}$	ii $12 \times \frac{4}{3}$	iii $12 \times \frac{3}{5}$	iv $12 \times \frac{3}{4}$	v $12 \times \frac{5}{3}$

- 2 Copy and complete the workings for these divisions. Remember to turn them into multiplications first, then cancel common factors.

a $12 \div \frac{2}{3} = 12 \times \frac{3}{2} = 6 \times 2 \times \frac{3}{2} = \square \times \square = \square$

b $18 \div \frac{3}{4} = 18 \times \frac{\square}{\square} = 6 \times 3 \times \frac{\square}{\square} = \square \times \square = \square$

c $20 \div \frac{4}{7} = 20 \times \frac{\square}{\square} = 5 \times 4 \times \frac{\square}{\square} = \square \times \square = \square$

d $30 \div \frac{2}{3} = 30 \times \frac{\square}{\square} = 15 \times 2 \times \frac{\square}{\square} = \square \times \square = \square$

e $24 \div \frac{4}{5} = 24 \times \frac{\square}{\square} = \square \times 4 \times \frac{\square}{\square} = \square \times \square = \square$

Tip

In part **a**, 2 is the common factor, so cross out the 2s.

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8 Fractions

- 3 Copy and complete the workings for these divisions.

a $15 \div \frac{6}{7} = 15 \times \frac{7}{6} = 5 \times 3 \times \frac{7}{3 \times 2} = \frac{5 \times \square}{2} = \frac{\square}{2} = \square \frac{\square}{2}$

b $12 \div \frac{8}{9} = 12 \times \frac{\square}{\square} = 3 \times 4 \times \frac{9}{\square \times \square} = \frac{3 \times 9}{2} = \frac{\square}{2} = \square \frac{\square}{2}$

c $20 \div \frac{6}{5} = 20 \times \frac{\square}{\square} = 10 \times 2 \times \frac{5}{\square \times \square} = \frac{\square \times \square}{\square} = \frac{\square}{\square} = \square \frac{\square}{3}$

d $15 \div \frac{10}{13} = 15 \times \frac{\square}{\square} = 3 \times 5 \times \frac{13}{\square \times \square} = \frac{\square \times \square}{\square} = \frac{\square}{\square} = \square \frac{\square}{\square}$

Tip

In part **a**, rewrite 15 as 5×3 and rewrite 6 as 3×2 . 3 is the common factor, so cross out the 3s.

- 4 Match each question card with the correct answer card.

answer will always be a proper fraction.



as $\frac{1}{4} \div \frac{1}{2}, \frac{1}{2} \div \frac{2}{3}$
and $\frac{7}{8} \div \frac{1}{4}$

Use specialising to decide if Sofia's generalisation is correct.

- 10 Work out these divisions. Write each answer in its simplest form and as a mixed number when appropriate. Show how to check your

answers are correct using inverse operations.

a $\frac{1}{4} \div \frac{3}{5}$

b $\frac{4}{5} \div \frac{1}{6}$

c $\frac{4}{7} \div \frac{12}{13}$

d $\frac{9}{10} \div \frac{3}{4}$

Challenge

- 11 Work out each calculation.

a $\left(1 - \frac{3}{4}\right) \div \left(1 - \frac{2}{7}\right)$

b $\left(\frac{2}{3} + \frac{5}{9}\right) \div \frac{5}{6}$

c $4\frac{3}{5} - 5\frac{1}{5} \div 1\frac{2}{3}$

- 12 It takes a chef $\frac{1}{4}$ of an hour to prepare 5 kg of vegetables.
What mass of vegetables can the chef prepare in $2\frac{1}{2}$ hours?

- 13 The length of a rectangle is $3\frac{1}{3}$ m. The area is $9\frac{1}{6}$ m².
What is the width of the rectangle? Give your answer as a mixed number in its simplest form.

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8 Fractions

- 14 When you simplify a ratio $A : B$ into the form $1 : n$, you need to divide both numbers by A .

So $A : B = \frac{A}{A} : \frac{B}{A} = 1 : \frac{B}{A}$ For example: $3 : 5 = \frac{3}{3} : \frac{5}{3} = 1 : \frac{5}{3} = 1 : 1\frac{2}{3}$

Marcus is looking at the ratio $3\frac{1}{4} : 9\frac{3}{8}$. He makes this conjecture:

Without actually calculating the answer, I estimate that the ratio simplifies to approximately 1 : 3.



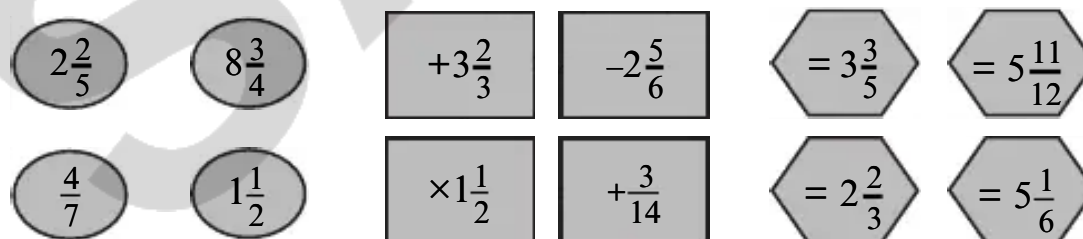
- a Explain how Marcus estimated this simplified ratio.

- b** Copy and complete the working to write the ratio $3\frac{1}{4} : 9\frac{3}{8}$ in the form $1 : n$, where n is a mixed number in its simplest form.

$$3\frac{1}{4} : 9\frac{3}{8} = \frac{13}{4} : \frac{75}{8} = \frac{13}{4} : \frac{75}{8} = 1 : \frac{75}{8} \times \frac{4}{13} = 1 : n$$

- c** Use your answer to part **b** to decide if Marcus's estimate is a good estimate of the accurate ratio $1 : n$.
- d** Write the ratio $6\frac{1}{2} : 4\frac{1}{3}$ in the form $1 : n$, where n is a fraction in its simplest form.
- e** Write the ratio $4\frac{1}{7} : 5\frac{4}{5}$ in the form $1 : n$, where n is a mixed number in its simplest form.

- 15** Sort these cards into four sets of correct calculations. There must be one oval card, one rectangular card and one hexagonal card in each set.



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8.5 Making calculations easier

> 8.5 Making calculations easier

Exercise 8.5

Focus

Key word
strategies

- 1** Work out the answer to each calculation. Some working has been shown to help you.

a $\frac{1}{2} + 1.5^2 + 9 \Rightarrow \frac{1}{2} + 1\frac{1}{2}^2 = \square^2 = \square \Rightarrow \square + 9 = \square$

b $\left(2\frac{3}{5} - 0.6\right)^3 - 3 \Rightarrow \left(2\frac{3}{5} - \frac{3}{5}\right)^3 = (\square)^3 = \square \Rightarrow \square - 3 = \square$

c $5^2 - \left(4\frac{1}{4} + 0.75\right) \Rightarrow \left(4\frac{1}{4} + \frac{3}{4}\right) = \square \Rightarrow 5^2 = \square \Rightarrow \square - \square = \square$

2 Work out these calculations. Use the same **strategy** as in Question 1.

a $10 \times \left(2.5 + 5\frac{1}{2}\right)$ b $\left(3.3 + 5\frac{7}{10}\right)^2$ c $6 \times 1.2 - 2\frac{3}{5}$

3 Work out the answers to these calculations. Some working has been shown to help you.

a $3.5 \times 1.5 \times 12 \Rightarrow \frac{7}{2} \times \frac{3}{2} = \frac{\square}{4} \Rightarrow \frac{\square}{4^1} \times 12^3 = \square \times 3 = \square$

b $1.75 \times 2\frac{1}{2} \times 32 \Rightarrow \frac{7}{4} \times \frac{5}{2} = \frac{\square}{8} \Rightarrow \frac{\square}{8^1} \times 32^4 = \square \times 4 = \square$

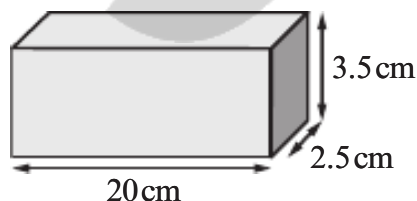
c $4.7 \times 35 \Rightarrow 4\frac{7}{10} \times 35 = \frac{\square}{10} \times 35 \Rightarrow \frac{\square}{10^2} \times 35^7 = \frac{\square}{2} = \square \frac{\square}{2}$

4 Work out these calculations. Use the same strategy as in Question 3.

a $1.5 \times 2.5 \times 12$ b $3.25 \times 1\frac{1}{2} \times 48$ c 3.3×15

Practice

5 Work out the volume of this cuboid.



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8 Fractions

6 Work out the answers to these calculations. Some working has been shown to help you.

a $0.44 \times 5^2 \Rightarrow 0.44 = \frac{44}{100}, 5^2 = 25 \Rightarrow \frac{44}{100} \times 25 = \square$

b $0.9 \times 6\frac{2}{3} \Rightarrow 0.9 = \frac{9}{10}, 6\frac{2}{3} = \frac{20}{3} \Rightarrow \frac{9}{10} \times \frac{20}{3} = \square$

c $2.4 \times (3^3 - 7) \Rightarrow 2.4 = \frac{24}{10}, 3^3 - 7 = \square \Rightarrow \frac{24}{10} \times \square = \square$

7 Work out these calculations. Use the same strategy as in Question 6.

a $1.6 \times \frac{5}{8}$ b 0.48×52 c 0.456×53

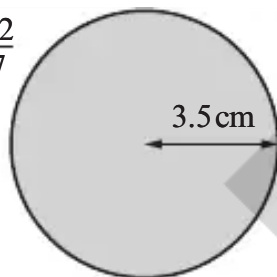
8 The diagram shows a triangle. Work out the area of the triangle.



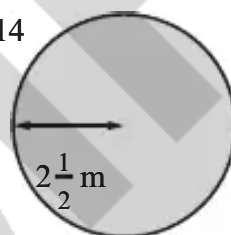


- 9 Work out the area of each circle. Use the given values of π .

a $\pi = \frac{22}{7}$



b $\pi = 3.14$



Challenge

- 10 The area of this compound shape is $3\frac{4}{15} \text{ m}^2$.

Work out the height of the triangle.

- 11 Work out $2.5^2 + \sqrt{6\frac{1}{4}}$

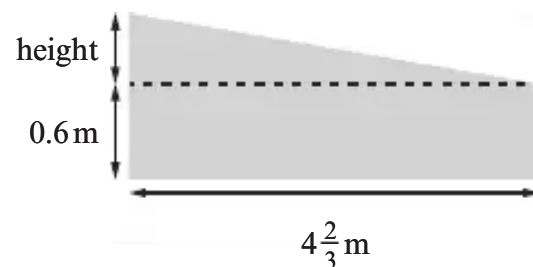
- 12 Here are three expression cards.

A $1.5(2x - 1)$

B $4 \times 2.5 \times \sqrt{\frac{1}{2}x}$

C $\frac{(x + 1.5)^2}{2}$

When $x = 4\frac{1}{2}$, the three cards form a sequence. Work out the 50th term of the sequence.



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8.5 Making calculations easier

- 13 Arun uses this formula in a maths lesson.

$$V = \frac{1}{3} \pi r^2 h$$

- a Use the formula to work out the value of V when $r = 3.5$ and $h = 12$. Use $\pi = \frac{22}{7}$
- b This is how Arun rearranges the formula to make r the subject:

$$\frac{1}{3} \pi r^2 h = V \Rightarrow \pi r^2 h = 3V \Rightarrow r^2 = \frac{3V}{\pi h} \Rightarrow r = \sqrt{\frac{3V}{\pi h}}$$

Use your values of V , r and h from part a to show that Arun has rearranged the formula correctly.

- c Use the formula in part b to work out the value of r when

Tip

Simplify $\frac{3V}{\pi h}$ first, then square root it.

$V = 27$ and $h = 154$.

Check your answer is correct by substituting $h = 154$ and your value for r into the original formula.

then square root the answer.



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9

Sequences and functions

>

9.1 Generating sequences

This sequence of numbers is a **linear sequence**: 2, 5, 8, 11, 14, ... In a linear sequence, the terms increase or decrease by the same amount each time. The term-to-term rule for this sequence is 'Add 3'.

Key words

linear sequence

This sequence of numbers is a **non-linear sequence**: 2, 5, 9, 14, 20, ...
In a non-linear sequence, the terms increase or decrease by a different amount each time. The term-to-term rule for this sequence is ‘Add 3, add 4, add 5, add 6, ...’.

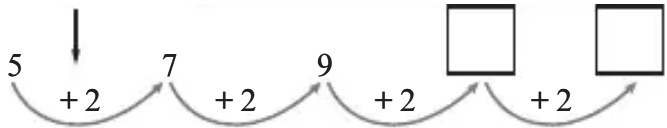
non-linear
sequence

Exercise 9.1

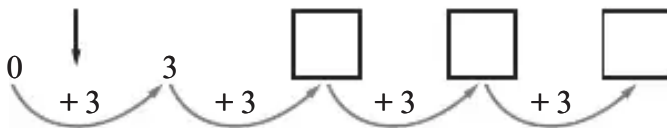
Focus

1 Write the first five terms of each linear sequence. Some of them have been started for you.

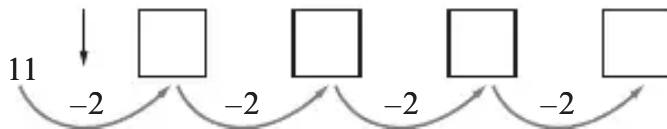
a 1st term: 5 term-to-term rule: ‘add 2’



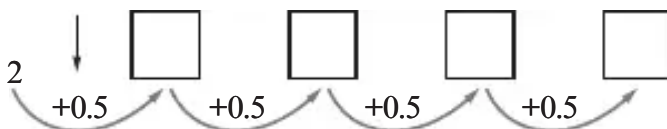
b 1st term: 0 term-to-term rule: ‘add 3’



c 1st term: 11 term-to-term rule: ‘subtract 2’



d 1st term: 2 term-to-term rule: ‘add 0.5’



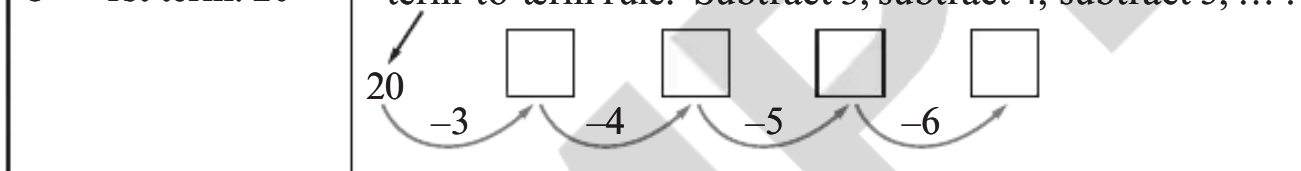
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9.1 Generating sequences

e 1st term: 210 term-to-term rule: ‘subtract 20’ 210

2 Write the first five terms of each non-linear sequence. Some of them have been started for you.

a 1st term: 4	term-to-term rule: ‘Add 1, add 2, add 3, ...’
b 1st term: 5	term-to-term rule: ‘Add 2, add 4, add 6, ...’
c 1st term: 20	term-to-term rule: ‘Subtract 3 subtract 4 subtract 5 ...’



- 3 Look at these sequences. Two of them are linear and two are non-linear. Write 'linear' or 'non-linear' for each sequence.

- a 0, 3, 8, 15, 24, b 18, 20, 22, 24, 26,
 c 30, 25, 20, 15, 10, d 50, 49, 47, 44, 40,

- 4 Look at these sequences. Write 'linear' or 'non-linear' for each sequence.

- a 15, 19, 23, 27, 31, b 6, 7, 9, 12, 16,
 c $4\frac{1}{2}$, 6, $7\frac{1}{2}$, 9, $10\frac{1}{2}$, d 100, 93, 86, 79, 72,
 e 50, 46, 41, 35, 28, f 1, -2, -5, -8, -11,

- 5 Write the first four terms of each of these sequences.

- a First term is 9, term-to-term rule is 'subtract 4'.
 b First term is 12, term-to-term rule is 'add 5'.
 c First term is 3, term-to-term rule is 'add 1, add 2, add 3, '.
 d First term is 10, term-to-term rule is 'subtract 1, subtract 2, subtract 3, '.
 e First term is 64, term-to-term rule is 'divide by 2, then add 8'.
 f First term is 8, term-to-term rule is 'subtract three, then multiply by 2'.

9 Sequences and functions

Practice

- 6 Cards **A** to **D** show term-to-term rules. Cards **i** to **iv** show sequences which all have a first term of 1.

A square, then add two	B add two, then square	C square, then subtract two	D subtract two, then square
i 1, -1, -1, ...	ii 1, 9, 121, ...	iii 1, 1, 1, ...	iv 1, 3, 11, ...

Match each term-to-term rule with the correct sequence.

- 7 Work out the first three terms of these sequences.

- a first term 5 term-to-term rule: 'square, then subtract 19'
 b first term -1 term-to-term rule: 'square, then add 1'
 c first term 4 term-to-term rule: 'subtract 3, then square'
 d first term -2 term-to-term rule: 'add 2, then square'

- 8 Copy these linear sequences and fill in the missing terms

a $3, 4\frac{1}{3}, \square, 7, \square, 9\frac{2}{3}, \square$

b $10, 9\frac{1}{5}, \square, 7\frac{3}{5}, \square, 6, \square$

c $-6, \square, \square, -4.8, -4.4, \square, \square$

d $\square, \square, 5, 3.75, \square, \square, 0$

9 The first three terms of a sequence are 3, 10, 38, ...

a Which of these cards, **A**, **B** or **C**, shows the correct term-to-term rule?

A square and add 1

B multiply by 4 and subtract 2

C cube and subtract 17

b Which is the first term in this sequence to be greater than one thousand? Show your working.

Tip

'Square and add 1' means the same as 'square, then add 1'.

10 Write the first four terms of each non-linear sequence.

a first term is 7 term-to-term rule is 'add 1, add 3, add 5, ...'

b first term is 15 term-to-term rule is 'add 4, add 7, add 10, ...'

c first term is 17 term-to-term rule is 'subtract 2, subtract 4, subtract 6, ...'

d first term is 32 term-to-term rule is 'subtract 8, subtract 12, subtract 16, ...'

9.1 Generating sequences

11 a Work out the third term in each sequence.

A first term is 3 term-to-term rule is 'subtract 1 and cube'

B first term is -2 term-to-term rule is 'add 3 and cube'

C first term is -3 term-to-term rule is 'power 4 and subtract 77'

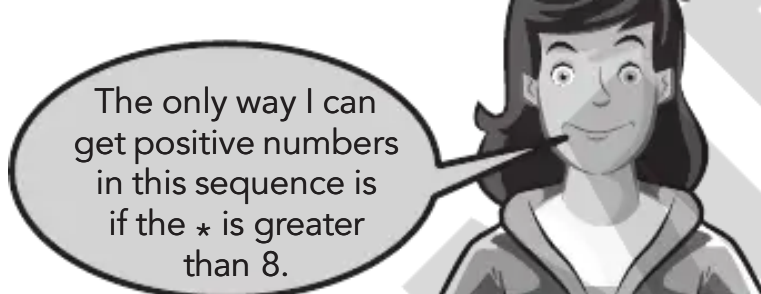
b Write your answers to **A**, **B** and **C** in order of size, starting with the smallest.

Challenge

12 Sofia makes her own sequence. This is what she writes.

*First term is -2, term-to-term rule is cube and add *.*

Sofia says:



Is Sofia correct? Justify your answer.

- ✦ 13 This is part of Timo's homework.

Question

The 5th term of a sequence is 72.

The term-to-term rule is multiply by 2 and subtract 8.

What is the 3rd term of the sequence?

Answer

$$4\text{th term} = 72 - 8 = 64, 64 \times 2 = 128$$

$$3\text{rd term} = 128 - 8 = 120, 120 \times 2 = 240$$

Is Timo's method correct? Explain your answer. Show all your working.

9 Sequences and functions

- 14 The fifth term of a sequence is 23. The term-to-term rule is multiply by $\frac{1}{2}$ and add 12.

Work out the second term in the sequence.

- ✦ 15 The first term of a sequence is -4 . The term-to-term rule is square and subtract 14.

How many negative terms are there in this sequence?

Show working to justify your answer.

- ✦ 16 This is Gina's homework. There is a mark covering one of the numbers.

Question

The third term of a sequence is 0.

The fourth term of the sequence is 512.

The term-to-term rule is add \blacksquare and cube.

What is the first term of the sequence?

What is the answer to Gina's homework? Show how you worked out your answer.

> 9.2 Using the n th term

Exercise 9.2

Focus

Key words

quadratic
sequence

- 1 Copy and complete the workings to find the first four terms of these sequences.

a n th term is $3n$ 1st term = $3 \times 1 = 3$ 2nd term = $3 \times 2 = \square$
 3rd term = $3 \times 3 = \square$ 4th term = $3 \times 4 = \square$

b n th term is $\frac{1}{4}n$ 1st term = $\frac{1}{4} \times 1 = \frac{1}{4}$ 2nd term = $\frac{1}{4} \times 2 = \frac{2}{4} = \frac{\square}{2}$
 3rd term = $\frac{1}{4} \times 3 = \frac{\square}{4}$ 4th term = $\frac{1}{4} \times 4 = \frac{\square}{\square} = \square$

c n th term is n^2 1st term = $1^2 = 1$ 2nd term = $2^2 = \square$
 3rd term = $3^2 = \square$ 4th term = $4^2 = \square$

d n th term is n^3 1st term = $1^3 = 1$ 2nd term = $2^3 = \square$
 3rd term = $3^3 = \square$ 4th term = $4^3 = \square$

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9.2 Using the n th term

- 2 Copy and complete the workings to find the first three terms and the 10th term of these sequences.

a n th term is $6n + 1$ 1st term = $6 \times 1 + 1 = 7$ 2nd term = $6 \times 2 + 1 = \square$
 3rd term = $6 \times 3 + 1 = \square$ 10th term = $6 \times 10 + 1 = \square$

b n th term is $n^2 - 1$ 1st term = $1^2 - 1 = 0$ 2nd term = $2^2 - 1 = \square$
 3rd term = $3^2 - 1 = \square$ 10th term = $10^2 - 1 = \square$

c n th term is $\frac{1}{2}n$ 1st term = $\frac{1}{2} \times 1 = \frac{1}{2}$ 2nd term = $\frac{1}{2} \times 2 = \frac{2}{2} = \square$
 3rd term = $\frac{1}{2} \times 3 = \frac{\square}{2} = \square$ 10th term = $\frac{1}{2} \times 10 = \frac{\square}{2} = \square$

d n th term is $\frac{n}{2}$ 1st term = $\frac{1}{2}$ 2nd term = $\frac{\square}{2} = \square$
 3rd term = $\frac{\square}{2} = \square$ 10th term = $\frac{\square}{2} = \square$



3

- a What do you notice about your answers to Question 2 parts c and d?
- b Copy and complete these statements. The first one has been done for you.
- i The sequence $\frac{1}{2}n$ is the same as $\frac{n}{2}$
- ii The sequence $\frac{1}{3}n$ is the same as $\frac{n}{\boxed{}}$
- iii The sequence $\frac{1}{5}n$ is the same as $\frac{\boxed{}}{\boxed{}}$
- iv The sequence $\frac{3}{4}n$ is the same as $\frac{3n}{\boxed{}}$

- 4 The cards A to F show the n th term rules for six different sequences. The cards i to vi show the 8th term of these sequences. Match each card A to F with the correct card i to vi. The first one has been done for you: A and iv.

A $n + 12$	B $2n + 1$	C $n^2 - 40$	D $\frac{1}{4}n + 10$	E $3n - 10$	F $\frac{n}{8} + 12$
i $\boxed{17}$	ii $\boxed{13}$	iii $\boxed{14}$	iv $\boxed{20}$	v $\boxed{24}$	vi $\boxed{12}$

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9 Sequences and functions

Practice

- 5 Work out the first three terms and the 10th term of the sequences with the given n th terms.
- a $8n + 7$ b $7n - 8$ c $\frac{1}{2}n - 4$ d $\frac{n}{10}$ e $n^2 + 20$
- 6 Match each sequence card A to D with the correct n th term expression card i to iv.
- | | | | |
|----------------------------|--|----------------------------|--------------------------|
| A 1, 8, 27, 64, ... | B $\frac{1}{3}, \frac{2}{3}, 1, \frac{4}{3}, \dots$ | C 3, 6, 11, 18, ... | D 2, 3, 4, 5, ... |
| i $\frac{2}{n+2}$ | ii $n+1$ | iii $\frac{n}{3}$ | iv $\frac{3}{n}$ |
- 7 The cards show one term from two different sequences.
- | | |
|---|--|
| A 11th term in the sequence
n th term is $n^2 - 33$ | B 120th term in the sequence
n th term is $\frac{2}{3}n + 7$ |
|---|--|



- 8** Decide if each of these sequences is linear, quadratic or neither. Show your working.

- 9** Work out the n th term rule for each of these quadratic sequences.

- 10** Look at this number sequence: 7, 10, 15, 22, 31,
Just by looking at the numbers in the sequence, explain how you know that the n th term rule for this sequence cannot be $n^2 - 10$.

- 11** What is the n th term rule for each of these sequences?

- Tip

Remember:
In a linear sequence the terms increase or decrease by the same amount every time. In a **quadratic sequence** the second differences are the same.

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9.2 Using the n th term

Challenge

- 12** The cards **A**, **B** and **C** show one term from three different sequences.

A 9th term in the sequence.
 n th term is $\frac{n}{15}$

B 10th term in the sequence.
 n th term is $\frac{n}{16}$

C 8th term in the sequence.
 n th term is $\frac{n}{14}$

- a** Work out the term for each card.
- b** Write your answers to part **a** in order of size, starting with the smallest.

- 13** Work out the answers to these questions. Show working to support your decisions.

- a** The n th term rule for a sequence is $n^2 + 34$. Is the number 292 a term in this sequence?

- b** The n th term rule for a sequence is n^3 . Is the number 5832 a term in this sequence?
- 14** Work out an expression for the n th term for each sequence.
- a** $8\frac{2}{3}, 9, 9\frac{1}{3}, 9\frac{2}{3}, \square$ **b** $12.5, 12.2, 11.9, 11.6, \square$
- c** $-3\frac{1}{4}, -3\frac{3}{4}, -4\frac{1}{4}, -4\frac{3}{4}, \square$ **d** $0, -3.5, -7, -10.5, \square$
- 15** The n th term rule for a sequence is $n^2 + 2n - 1$.
This is how you work out the 5th term in the sequence:
- a** Work out the first three terms in the sequence.
- b** Work out the 10th term in the sequence.
- 16** Use the n th term rules to work out the first three terms and the 10th term for each of these sequences.
- a** $n^2 + 5n + 3$ **b** $3n^2 - 2$ **c** $2n^2 - 3n + 10$

$$\begin{aligned} \text{5th term} &= 5^2 + 2 \times 5 - 1 \\ &= 25 + 10 - 1 \\ &= 34 \end{aligned}$$

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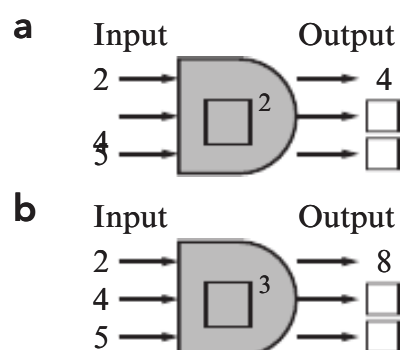
9 Sequences and functions

> 9.3 Representing functions

Exercise 9.3

Focus

- 1** Copy and complete the outputs for these function machines.

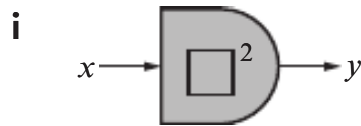


Tip

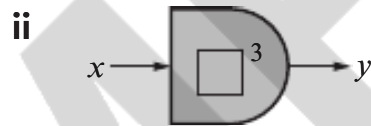
$$\begin{aligned} 2^2 &= 4, 4^2 = \square, \\ 5^2 &= \square \\ 2^3 &= 8, 4^3 = \square, \\ 5^3 &= \square \end{aligned}$$

- 2** **a** Copy and complete the table of values for each function machine

2 a Copy and complete the table of values for each function machine.



x	2	4	5
y			



x	2	4	5
y			

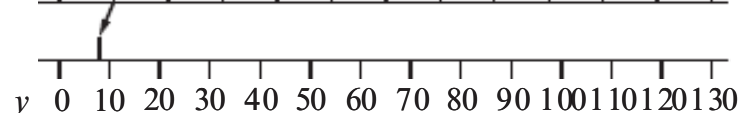
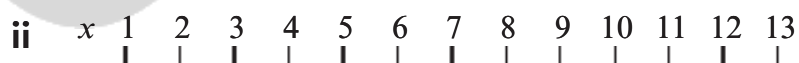
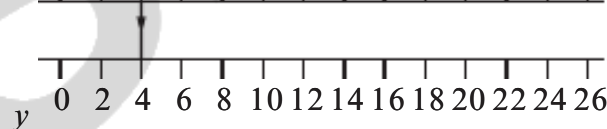
b What do you notice about your answers to parts a i and a ii and your answers to Question 1?

c Copy and complete the equation for each function in part a.

i $y = x \square$

ii $y = x \square$

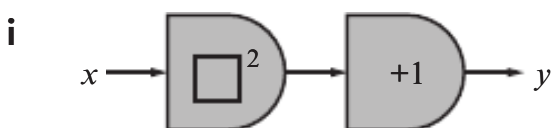
d Copy and complete the mapping diagram for each function in part a.



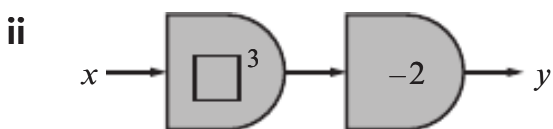
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9.3 Representing functions

3 a Copy and complete the table of values for each two-step function machine. Use the working to help you.



x	3	6	8
y	10		



x	1	3	10
y	-1		

b Copy and complete the equation for each function in part a.

i $y = x \square + \square$

ii $y = x \square - \square$

4 a Copy and complete the table of values for each two-step function machine. All the answers are in the cloud.

Tip

$3^2 = 9$ and $9 + 1 = 10$

$6^2 = \square$ and
 $\square + 1 = \square$

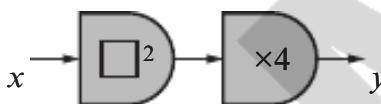
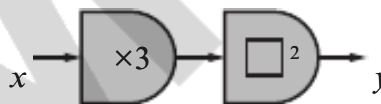
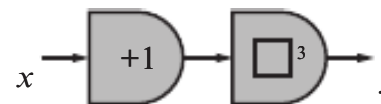
$8^2 = \square$ and
 $\square + 1 = \square$

$1^3 = 1$ and
 $1 - 2 = -1$

$3^3 = 27$ and
 $27 - 2 = \square$

$10^3 = \square$ and
 $\square - 2 = \square$

0	4	9	16	25
27	81	125	144	

i  ii  iii 

x	-2	1	3
y			

x	-1	3	4
y			

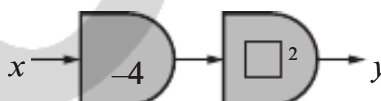
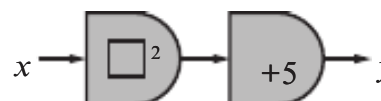
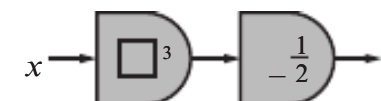
x	-1	2	4
y			

b Copy and complete the equation for each function in part a.

i $y = \square x \square$ ii $y = (\square x) \square$ iii $y = (x + \square) \square$

Practice

5 a Copy and complete the table of values for each two-step function machine.

i  ii  iii 

x	-2	0	12
y			

x	-3	2	$\frac{1}{2}$
y			

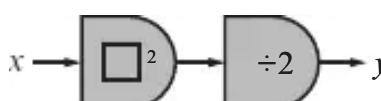
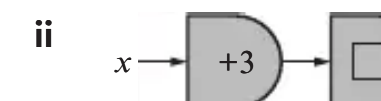
x	-3	$-\frac{1}{2}$	$\frac{1}{2}$
y			

b Write each function in part a as an equation.

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9 Sequences and functions

- 6 a Draw a function machine for the equation $y = (2x)^2$.
b Draw a table of values for $x = \frac{1}{8}, \frac{1}{4}, \frac{1}{2}$ and 2. Work out the values of y for the function $y = (2x)^2$.
- 7 a Work out the missing values in the tables for these function machines. The missing x -values are all **negative**.

i  ii 

x	2		-6	
y		8		50

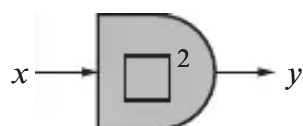
x	5		-15	
y		0		16

b Write each function in part a as an equation.



8

A




Sofia makes this conjecture about function A:

B




Zara makes this conjecture about function B:

function A:



I think that because the function is $y = x^2$, when you have the positive and negative of the same value for x , the y -value will be the same.

about function B:



I think that because the function includes a square, when you have the positive and negative of the same value for x , the y -value will be the same.

Is either of them correct? Justify your answer. Show all your working.

- 9

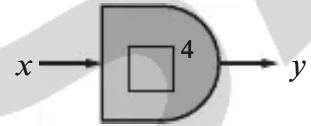
For each of these function machines

i write the equation

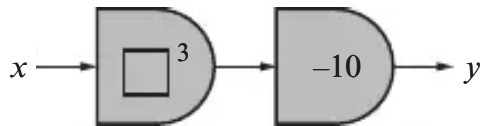
ii work out the reverse equation

iii show how to check your equations are correct.

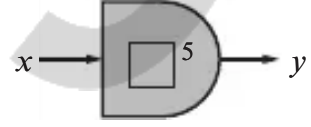
a



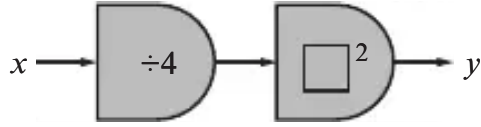
d



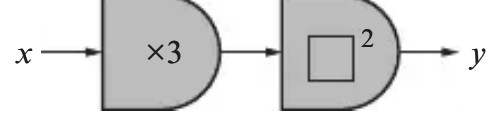
b



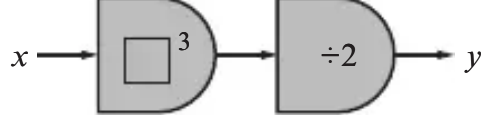
e



c



f



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9.3 Representing functions

Challenge

10

a

Sort these function equations into groups. Explain how you chose the groups by describing the characteristics of each group.

A $y = x^2 - 4$

B $y = \sqrt{x}$

C $y = \frac{x^3}{2}$

D $y = \left(\frac{x}{4}\right)^2$

E $y = \frac{\sqrt[3]{x}}{4}$

F $y = x^2$

G $y = 9x$

H $y = (9x)^3$

I $y = \sqrt{\frac{x}{9}}$

J $y = (x + 2)^2$

K $y = \sqrt[3]{x + 9}$

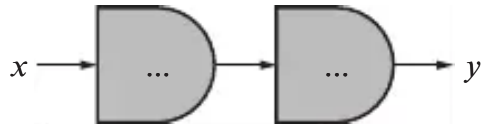
L $y = x - 4$

b

Now sort the function equations into different groups. Explain how you chose the groups by describing the characteristics of each group.

11

Sofia and Zara are looking at this function machine and table of values.



x	4	8	10
y	4	16	25

Sofia says:



I think the reverse equation for this function is $x = \sqrt{4y}$.

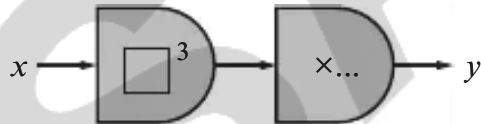
Zara says:



I think the reverse equation for this function is $x = 2\sqrt{y}$.

Is either of them correct? Explain your answer. Show all your working.

- 12 Copy and complete this function machine, its equation and table of values.



x	$\frac{1}{2}$	$\frac{1}{4}$	
y	$1\frac{1}{4}$		-270

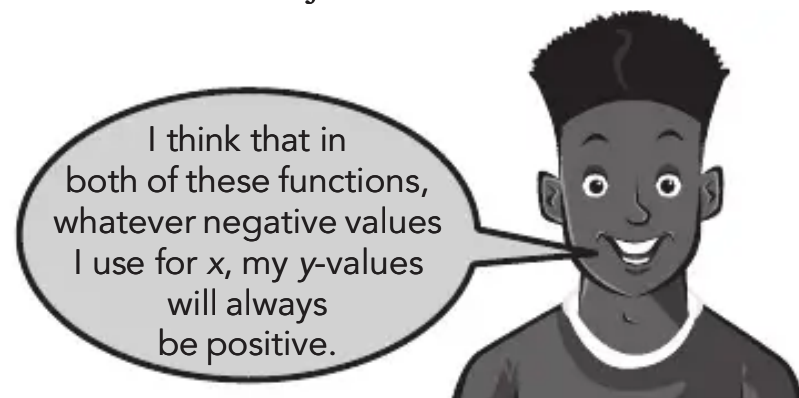
$y = \dots$

Explain how you worked out your answer.

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9 Sequences and functions

- 13 Marcus is looking at the two functions $y = (x - 5)^4$ and $y = 5 - x^5$. He makes this conjecture.



I think that in both of these functions, whatever negative values I use for x, my y-values will always be positive.

Is Marcus correct? Show working to justify your answer.



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10 Graphs

> 10.1 Functions

Exercise 10.1

Focus

- 1 The membership cost at a fitness club is a joining fee of \$20 plus \$15 per week.
 - a Show that the total cost for 4 weeks is \$80.
 - b Find the total cost for 10 weeks.
 - c The total cost for w weeks is y dollars. Write a function for y .

- c The total cost for w weeks is y dollars. Write a function for y .
- 2 At a gym, Arun lifts 2 kg and 4 kg weights.
- Find the total mass of four 2 kg weights and three 4 kg weights.
 - Aran lifts x 2 kg weights and y 4 kg weights. The total mass is 22 kg. Write a function to show this.
- 3 Alicia is a years old and Barak is b years old. The total of their ages is 36 years.
- Write a function to show this.
 - Alicia is 13. Work out Barak's age.
 - Barak is 3 times Alicia's age. Write a function to show this.

Practice

- 4 A small taxi can take 4 passengers. A large taxi can take 6 passengers.
- Work out the total number of passengers that 3 small taxis and 2 large taxis can take.
 - s small taxis and l large taxis can take 40 passengers.
 - Write a function to show this.
 - There are 7 small taxis. Work out the number of large taxis.

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10 Graphs

- 5 Gareth and Tanya run a race. Tanya's time is 20 minutes less than twice Gareth's time.
- Gareth's time is 52 minutes. Work out Tanya's time.
 - Gareth's time is g minutes and Tanya's time is t minutes. Write a function for t in terms of g .
 - Tanya's time is 52 minutes. Work out Gareth's time.
- 6 Zara has some tiles. Each tile is a pentagon or a hexagon.
- Work out the total number of vertices on 5 pentagons and 10 hexagons.
- The total number of vertices is 100.
- There are p pentagons and h hexagons. Write a function to show this.
 - Work out the largest possible number of hexagons.



Challenge

- 7 a Here is a function: $y = 20x + 10$
Describe a situation this function could represent.
Write what x and y represent.
- b Here is a function: $10c + 20d = 200$
Describe a situation this function could represent.
Write what c and d represent.



- 8 Here are five functions.

$x + y = 10$	$x = 10 - y$	$x + y - 10 = 0$	$y = 10 + x$	$2x + 2y = 20$
--------------	--------------	------------------	--------------	----------------

Which function is the odd one out? Give a reason for your answer.

- 9 In a game you must collect red counters and blue counters.
Red counters score 1 point and blue counters score 4 points.
Marcus has r red counters and b blue counters.
- a Marcus has a total of 18 counters. Write a function to show this.
- b Marcus' counters score 27 points. Write a function to show this.
- c Work out how many counters of each colour Marcus has.

Tip

'Odd one out' means 'different from the others'.

> 10.2 Plotting graphs

Exercise 10.2

Focus

Key words

linear function



- 1 Here is a **linear function**: $y = 5x + 12$
- a Copy and complete this table of values.
- | | | | | | | |
|-----|----|----|---|---|----|---|
| x | -1 | 0 | 1 | 2 | 3 | 4 |
| y | | 12 | | | 27 | |
- b Work out where the graph of $y = 5x + 12$ crosses the y -axis.
- c Show that $(5, 37)$ is on a graph of $y = 5x + 12$, but $(10, 74)$ is not on the graph.
- 2 Here is a function: $y = 0.2x + 10$
- a Copy and complete this table of values.
- | | | | | | | |
|-----|-----|---|----|----|----|----|
| x | -10 | 0 | 10 | 20 | 30 | 40 |
|-----|-----|---|----|----|----|----|

x	-10	0	10	20	30	40
y			12			

- b Work out where the graph of $y = 0.2x + 10$ crosses the y -axis.
- c The point $(7, a)$ is on a graph of $y = 0.2x + 10$. Work out the value of a .
- 3 Here is a function: $x + y = 20$
- a Copy and complete this table of values.

x	0	5	10	15	20	25
y			10			

- b Where does a graph of $x + y = 20$ cross the axes?

Practice

- 4 Here is a function: $2x + y = 10$

- a Copy and complete this table of values.

x	0	1	2	3	4	5	6
y			6		2		

- b Use the table to draw a graph of $2x + y = 10$.
- c The point $(c, 3)$ is on the graph. Work out the value of c .



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10 Graphs

- 5 Here is a function: $x + 3y = 12$
- a Copy and complete this table of values.

x	0	3		9		15
y			2		0	

- b Draw a graph of $x + 3y = 12$.
- c Where does the graph cross the line $x = 4.5$?

- 6 Here is a function: $3x + 2y = 18$

- a Copy and complete this table of values.

x	0		2	
y		0		1.5

- b Draw a graph of $3x + 2y = 18$.
- c Where does the graph cross the axes?

- 7 a Copy and complete this table of values for $y = x^2 - 3$.

x	-3	-2	-1	0	1	2	3
y	6					1	

Challenge

- 8 a** Copy and complete this table of values for the function $3x + 4y = 36$.

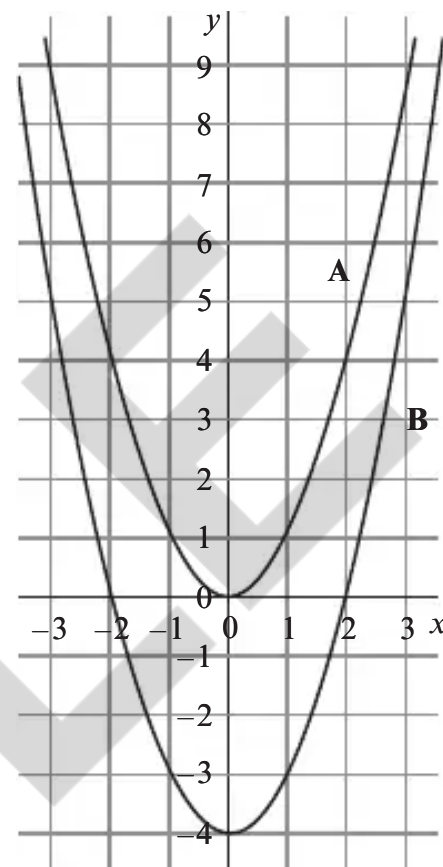
x	0		4	
y		0		3

- b** Use the table to draw a graph of $3x + 4y = 36$.
 - c** On the same axes draw a graph of $3x + 4y = 24$.
 - d** On the same axes draw a graph of $3x + 4y = 12$.
- 9** Here is a function: $6x + 5y = 60$.
 - a** Show that the point $(5, 6)$ is on a graph of $6x + 5y = 60$.
 - b** Work out where a graph of $6x + 5y = 60$ crosses the coordinate axes.
 - c** Draw a graph of $6x + 5y = 60$.

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10.3 Gradient and intercept

- 10**
 - a** Draw a graph of $x + 2y = 14$.
 - b** On the same axes draw a graph of $3x + y = 12$.
 - c** Write the coordinates of the point where the two lines cross. Check that the coordinates satisfy both equations.
- 11**
 - a** Work out the equation of each line, **A** and **B**.
 - b** Here is a point: $(-7, n)$. Work out the value of n if the point is on
 - i** line **A**
 - ii** line **B**.
 - c** The point $(k, 21)$ is on line **B**. Work out the possible values of k .



> 10.3 Gradient and intercept

Exercise 10.3

Focus

1 Write the gradient and y -intercept of each line.

a $y = 10x + 20$

b $y = 10 - 20x$

c $y = -2.5 + 0.5x$

2 Write the gradient and y -intercept of each line.

a $y = \frac{1}{3}x + \frac{10}{3}$

b $y = 12$

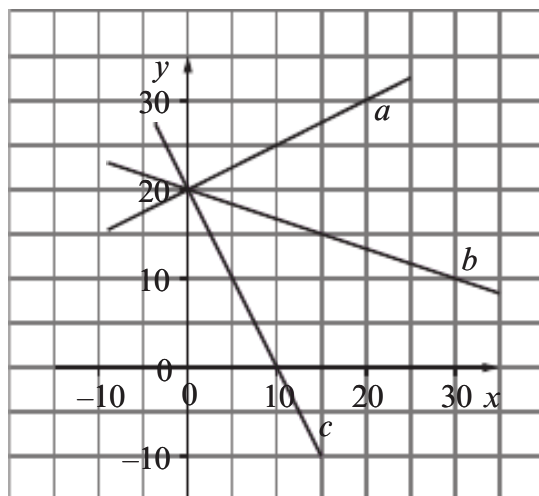
c $y = -30x - 45$

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10 Graphs

3 Work out the gradient of each of these lines.



Practice

4 Here is a function: $x + y = 15$

a Make y the subject of this function.

b Write the gradient and the y -intercept of the graph of $x + y = 15$.

- c Where does the graph of $x + y = 15$ cross the x -axis?
- 5 Here is a function: $x + 3y = 12$
- a Make y the subject of this function.
- b Write the gradient and the y -intercept of the graph of $x + 3y = 12$.
- c Copy and complete this table of values for $x + 3y = 12$.

x	0		6	
y		0		3

- d Draw a graph of $x + 3y = 12$.
- e Use your graph to check your answers to part b.
- 6 $4y = x - 10$ is the equation of a line.
- a Show that $(20, 2.5)$ is on the line.
- b Make y the subject of the equation.
- c Write the gradient and the y -intercept of the line.

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10.4 Interpreting graphs

Challenge

- 7 Here is the equation of a line: $3x + 5y = 10$
- Choose the correct answer to the following questions, **A**, **B**, **C** or **D**.
- a What is the gradient? **A** $\frac{3}{5}$ **B** $\frac{5}{3}$ **C** $-\frac{3}{5}$ **D** $-\frac{5}{3}$
- b What is the y -intercept? **A** 10 **B** $3\frac{1}{3}$ **C** 2 **D** -2
- 8 Match each curve **A** to **D** to the correct gradient **i** to **iv**.
- | | | | |
|-----------------------|------------------------|-----------------------|-----------------------|
| A $2x + y = 8$ | B $2x + 4y = 8$ | C $y - 2x = 8$ | D $2y - x = 8$ |
|-----------------------|------------------------|-----------------------|-----------------------|
- | | | | |
|------------------------|--------------------------|--------------|--------------|
| i $\frac{1}{2}$ | ii $-\frac{1}{2}$ | iii 2 | iv -2 |
|------------------------|--------------------------|--------------|--------------|
- 9 Find the gradient and the y -intercept of each line.
- a $2x + 10y = 20$ b $10x + 4y = 20$ c $25x + 25y = 10$
- 10 The equation of a linear graph is $4y - 2x + 8 = 20$.
- a Show that $(-6, 0)$ is on the line.
- b Show that $(4, 5)$ is on the line.
- c Make y the subject of the equation.

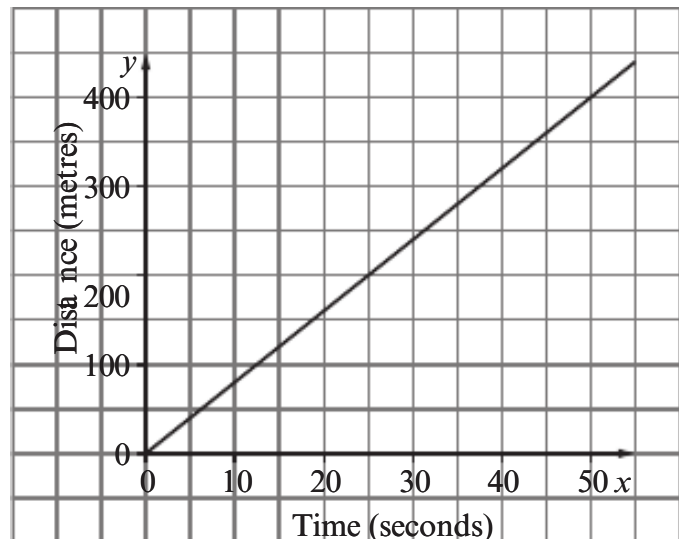
- d Write the gradient and the y -intercept of the line.

> 10.4 Interpreting graphs

Exercise 10.4

Focus

- 1 This graph shows the distance travelled by a cyclist.
 - a Find out the distance travelled after 50 seconds.
 - b Work out the gradient of the graph.
What does this tell you about the speed of the cyclist?
 - c The cyclist travels y metres in t seconds. Write an equation for the line.
 - d Use your equation to work out the distance travelled in 70 seconds.

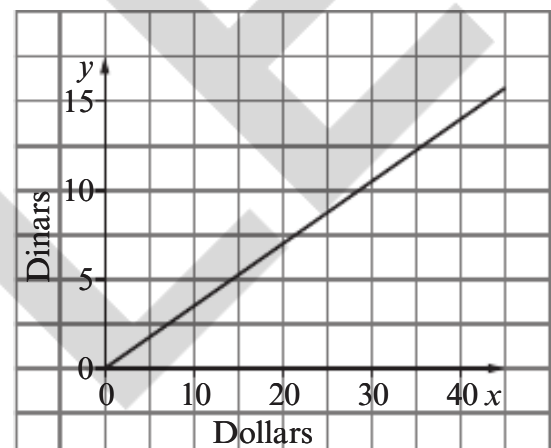
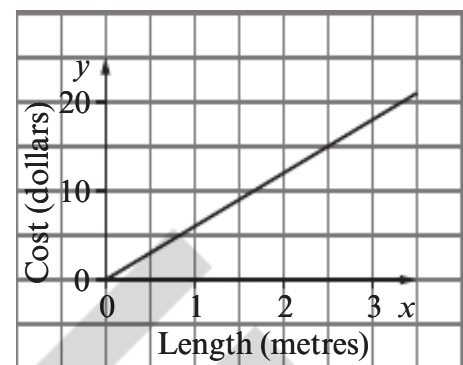


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10 Graphs

- 2 The cost of cloth depends on the length.
 - a Use the graph to find the cost of 2.5 metres of cloth.
 - b Work out the cost in dollars/metre.
 - c The cost of x metres is d dollars. Write an equation for the line.
 - d Work out the cost of 8.5 metres of cloth.
 - e Sofia pays 30 dollars. How many metres of cloth does she buy?
- 3 You can use this graph to convert dollars to dinars.
 - a How many dinars can you buy for
 - i 40 dollars
 - ii 20 dollars?
 - b How many dinars is 1 dollar worth?
 - c If x dollars are worth y dinars, write an equation for the line.
 - d How many dinars can you buy with 93 dollars?
 - e How many dollars are worth 700 dinars?



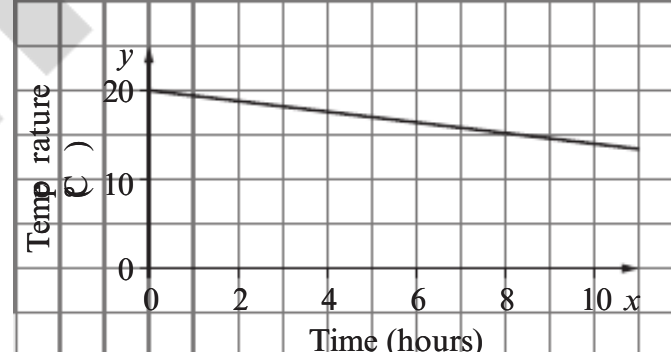
Practice

- 4 This graph shows the temperature inside a greenhouse.

a Copy and complete this table.

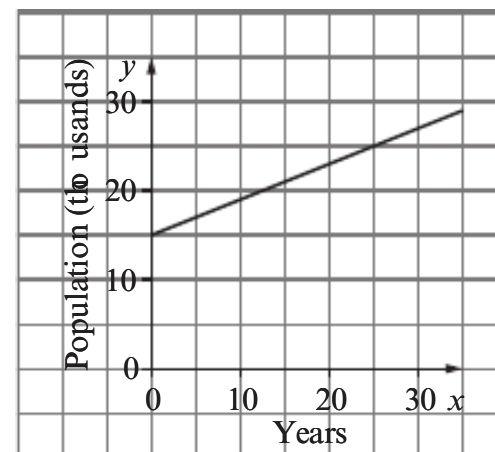
Time (hours)	0	5	10
Temperature ($^{\circ}\text{C}$)			

- b Work out the gradient of the line.
What does this tell you about how the temperature is changing?
- c The temperature is $y^{\circ}\text{C}$ after t hours. Write an equation for the line.
- d The temperature continues to decrease in the same way.
Work out the temperature after 12 hours.



- 5 This graph shows the changing population of a town.

- a Use the graph to find the population
i initially ii after 20 years iii after 30 years.
- b Work out the annual rate of increase of the population.
- c The population is p thousand people after t years.
Write an equation for the line.

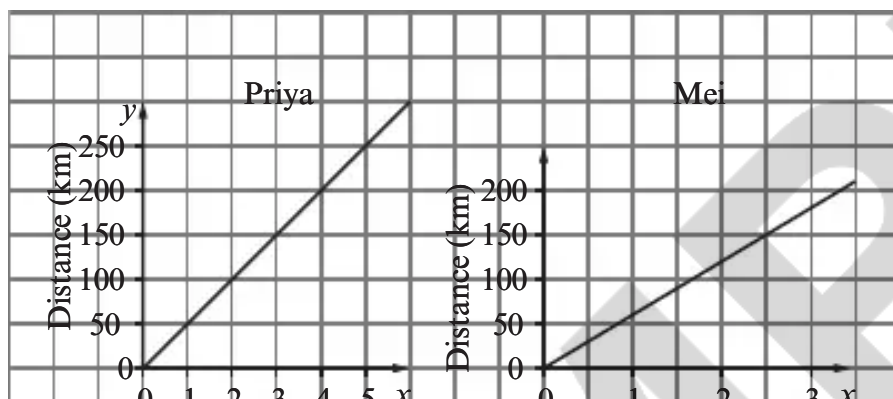


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10.4 Interpreting graphs

- 6 The price of 25 litres of petrol is 42 dollars.
- a Draw a graph to show the price of petrol.
- b Use your graph to estimate the cost of 18 litres of petrol.
- c The cost of l litres of petrol is d dollars. Write an equation for the graph. Show your method.
- d Use your equation in part c to check your answer to part b.
- e Work out the cost of 60 litres of petrol.
- f Mei pays 67.2 dollars. How many litres of petrol does she buy?

- 7 Priya and Mei are both driving cars. Here is a distance–time graph for each person.



- descends at a constant rate and reaches the ground after 120 seconds.
- a Draw a graph to show the changing height of the balloon.
 - b Use your graph to find the height after 90 seconds.
 - c Find the rate of descent in m/s.
 - d Work out an equation for your graph.



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11 Ratio and proportion

> 11.1 Using ratios

Exercise 11.1

Focus

- 1 To make pastry, Franco uses flour and butter in the ratio 2 : 1. He uses 250 g of flour to make pastry. Copy and complete the working to answer these questions.
 - a What mass of butter does Franco use?

flour: 2 parts = 250 g, so 1 part = $250 \div 2 = \square$ g

butter: 1 part = \square g

- b** What is the total mass of flour and butter in the pastry?

total = $250 + \square = \square$ g

- 2** A fruit drink contains pineapple juice and peach juice in the ratio 4:3.

There is 450 mL of peach juice in the drink. Copy and complete the working to answer these questions.

- a** How many millilitres of pineapple juice are in the drink?

peach juice: 3 parts = 450 mL, so 1 part = $450 \div 3 = \square$ mL

pineapple juice: 4 parts = $4 \times \square = \square$ mL

- b** How much fruit juice is in the drink altogether?

total = $450 + \square = \square$ mL

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11 Ratio and proportion

- 3** Copy and complete the working to answer this question.

All the missing numbers are in the cloud.

Tina and Kim share some money in the ratio 5:2. Tina gets \$65.
How much money do they share?

Tina: \square parts = \$65 \square part = $\square \div 5 = \$\square$

Kim: 2 parts = $\square \times 2 = \$\square$

total they share = $\square + \square = \$\square$

- 4** Three friends, Abdul, Benji and Caen share their water bill in the ratio 1:2:3.

Benji pays \$24. Copy and complete the working to answer

these questions.

- a** How much do Abdul and Caen pay?

Benji: 2 parts = \$24, 1 part = $\square \div 2 = \square$

Abdul: 1 part = \square

Caen: 3 parts = $3 \times \square = \$\square$

- b** What is the total cost of the bill?

total = $\square + \square + \square = \\square

13 1 91
26 5 65
65 2 26

Practice

- 5 Ahmad and Alicia share some sweets in the ratio 2 : 3. Ahmad gets 14 sweets.
- a How many sweets does Alicia get?
 - b How many sweets do they share?
- 6 A vegetable pie contains onions and broccoli in the ratio 5 : 3.
- The pie contains 300 g of onions.
- a What mass of broccoli is in the pie?
 - b What is the total mass of vegetables in the pie?
- 7 Three children share some pens in the ratio 2 : 5 : 8.
- The child with the most pens gets 24 pens.
- a How many pens do the other children get?
 - b How many pens do they share?



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11.1 Using ratios

- 8 This is part of Rohan's homework.

Question

Each month, Sion spends money on food, bills and travel in the ratio 4 : 7 : 5.

One month he spends \$40 on travel.

How much does Sion spend altogether on food, bills and travel in this month?

Answer

4 parts = \$40, so 1 part = $40 \div 4 = \$10$

total number of parts = $4 + 7 + 5 = 15$

total spent = $15 \times 10 = \$150$

- a Explain the mistakes Rohan has made.
 - b Write the correct solution.
- 9 Bikka makes some brown paint by

mixing blue, yellow and red paint in the ratio 2 : 5 : 6.



He uses 250 mL of yellow paint. How much brown paint does he make?

- 10 Zosia and Abie share some money in the ratio 4 : 5.
Abie gets \$15 more than Zosia.

- a How much money do they share?
b How much money do they each get?

- 11 Two numbers are in the ratio 3 : 4. One of the numbers is 12.
Show that the two possible values for the other number are 16 and 9.

- 12 Mia makes a cold iced drink.
She uses vanilla ice cream, grape juice and ginger ale in the ratio 1 : 4 : 5.

Mia has plenty of vanilla ice cream, but only 2250 mL of grape juice and 2750 mL of ginger ale.
She makes as much iced drink as she can with these ingredients.
How much of each ingredient does she use? Show how you worked out your answer.

11 Ratio and proportion

Challenge

- 13 Two numbers are in the ratio 6 : 5. One of the numbers is 0.03.
Work out the two possible values for the other number.
- 14 The sides of a quadrilateral are in the ratio 2 : 3 : 5 : 8. The difference between the shortest side and the longest side is 7.5 cm.
Work out the perimeter of the quadrilateral.

- 15 In a right-angled triangle, the difference between two of the angles is 20°.
a Work out the size of the angles in the triangle.
b How many solutions are there to part a? Explain why.
c For each solution to part a, write the ratio of the angles from smallest to biggest in its simplest form.

- 16 The table shows the child-to-staff ratios for various activities at an activity centre.
It also shows the number of children taking part in each activity on one day.
Each activity takes place at the same time, in a different area of the activity centre.

Activity	Child : staff ratio	Number of children
----------	---------------------	--------------------

Tip

The child : staff ratios show the maximum number of children allowed in each activity for one

Activity	Child:staff ratio	Number of children
Horse riding	4:1	22
Sailing	5:1	17
Rock climbing	8:1	30
Canoeing	10:1	26

member of staff.
For example, a
ratio of 4:1 shows
there can be no
more than four
children for one
member of staff.

- Show that the total number of staff needed to look after the children at the activity centre on this day is 17.
- On this day, only 15 staff are available. By moving as few children as possible, organise the groups so that only 15 staff are needed. Write the number of children doing each activity and explain how many children you have moved from one activity to another.

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11.2 Direct and inverse proportion

> 11.2 Direct and inverse proportion

Remember:

- two quantities are in direct proportion when both quantities increase or decrease in the same ratio
- two quantities are in **inverse proportion** when, as one quantity increases, the other quantity decreases in the same ratio.

Key words

inverse
proportion

Exercise 11.2

Focus

- Sam types 40 words in one minute.
 - How many words does he type in
 - 2 minutes
 - 3 minutes
 - 4 minutes?
 - Are the number of words Sam types and the number of minutes in direct or inverse proportion?

- 2 One bag of peanuts costs \$2.20.
- What is the total cost of
 - 2 bags
 - 3 bags
 - 4 bags?
 - Are the number of bags of peanuts and the total cost in direct or inverse proportion?
- 3 It takes 2 people 6 days to build a wall.
- When there are more people, does the job take more or less time?
 - When there are fewer people, does the job take more or less time?
 - Copy and complete the working to answer these questions.
 - There is one person. How long does it take them to build the wall?

$$\begin{array}{rclcl} \div 2 & \curvearrowright & 2 \text{ people} & = & 6 \text{ days} \\ & & 1 \text{ person} & = & \square \text{ days} \end{array} \quad \begin{array}{c} \curvearrowleft \\ \times 2 \end{array}$$

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11 Ratio and proportion

- There are 4 people. How long does it take them to build the wall?
- $$\begin{array}{rclcl} \times 2 & \curvearrowright & 2 \text{ people} & = & 6 \text{ days} \\ & & 4 \text{ people} & = & \square \text{ days} \end{array} \quad \begin{array}{c} \curvearrowleft \\ \div 2 \end{array}$$
- Are the number of people and the number of days to build the wall in direct or inverse proportion?
- 4 Jess runs from her house to the bus stop in 60 seconds.
- When she runs faster, does it take her more or less than 60 seconds?
 - When she runs slower, does it take her more or less than 60 seconds?
 - Copy and complete the working to answer these questions.
 - Jess runs twice as fast. How long does it take her to run from her house to the bus stop?
- $$\begin{array}{rclcl} \times 2 & \curvearrowright & \text{normal speed} & = & 60 \text{ seconds} \\ & & 2 \times \text{speed} & = & \square \text{ seconds} \end{array} \quad \begin{array}{c} \curvearrowleft \\ \div 2 \end{array}$$
- Jess runs half as fast. How long does it take her to run from her house to the bus stop?
- $$\begin{array}{rclcl} \div 2 & \curvearrowright & \text{normal speed} & = & 60 \text{ seconds} \\ & & \frac{1}{2} \text{ speed} & = & \square \text{ seconds} \end{array} \quad \begin{array}{c} \curvearrowleft \\ \times 2 \end{array}$$

- d Are the speed she runs and the time it takes her in direct or inverse proportion?
- 5 It takes 4 people 7 hours to build a shed. Copy and complete the working to answer these questions.
- a How long does it take 2 people to build the shed?
- $$\begin{array}{lcl} \div 2 & \swarrow & 4 \text{ people} = 7 \text{ hours} \\ & & \searrow \times 2 \\ & & 2 \text{ people} = \square \text{ hours} \end{array}$$
- b How long does it take 8 people to build the shed?
- $$\begin{array}{lcl} \times 2 & \swarrow & 4 \text{ people} = 7 \text{ hours} \\ & & \searrow \div 2 \\ & & 8 \text{ people} = \square \text{ hours} \end{array}$$
- c How many people are needed to build the shed in 1 hour?
- $$\begin{array}{lcl} \times 7 & \swarrow & 4 \text{ people} = 7 \text{ hours} \\ & & \searrow \div 7 \\ & & \square \text{ people} = 1 \text{ hour} \end{array}$$

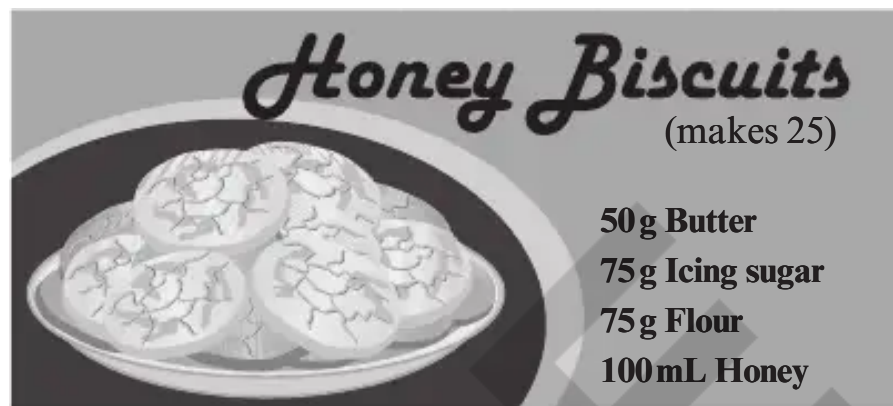
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11.2 Direct and inverse proportion

Practice

- 6 Here is a recipe for honey biscuits.
- a How much butter is needed for 50 biscuits?
- b How much flour is needed for 75 biscuits?
- c How much honey is needed for 100 biscuits?
- 7 It takes Hank 6 hours to drive a certain distance at an average speed of 80 km/h.
- a How long does it take Hank to drive the same distance at an average speed of
- i 160 km/h ii 40 km/h iii 120 km/h?
- b It takes Hank 8 hours to drive the same distance. What is his average speed?
- 8 The cost to rent a student house is a set price. Up to 8 students can live in the house.
- When 5 students rent the house, the cost per student is \$240 per month.



Copy and complete the table.

Number of students	5	2	3	4	6	7	8
Cost per student (\$)	240						

- 9 In a factory, 4 people can pack 20 boxes in 1 hour.
How long does it take 3 people to pack 20 boxes? Give your answer in hours and minutes.
- 10 It takes 8 people 5 days to dig a hole. How long does it take 10 people to dig the hole?
- 11 Zara is looking at this question.

It takes 20 minutes to travel by train from Pembroke to Tenby. There are 60 people on the train.
How long does the train take when there are 120 people on the train?



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11 Ratio and proportion

Zara says:

I think the train will take 40 minutes as the number of people has doubled.

$$60 \times 2 = 120, \text{ so} \\ 20 \times 2 = 40 \text{ minutes.}$$



What do you think? Justify your answer.

Challenge

- 12 The values of X and Y in the table are in direct proportion.

Work out the missing numbers A , B , C and D .

X	9	6	B	21	D
Y	21	A	35	C	17.5

- 13 Julio reads that the length of an adult's head and the length of their body are in direct proportion.

Julio's dad has a head length of 24 cm and a body length of 156 cm.

Using these measurements, work out

a the body length of an adult with a head length of 26 cm

b the total height of an adult with a body length of 143 cm

- 14 It takes 6 men 20 days to paint 4 houses.
- How many houses can 3 men paint in 20 days?
 - How many men does it take to paint 4 houses in 10 days?
 - How many days does it take 8 men to paint 4 houses?
 - Copy and complete the table.

Men	Days	Houses
6	20	4
1		4
1		1
6	60	
4	60	

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11.2 Direct and inverse proportion

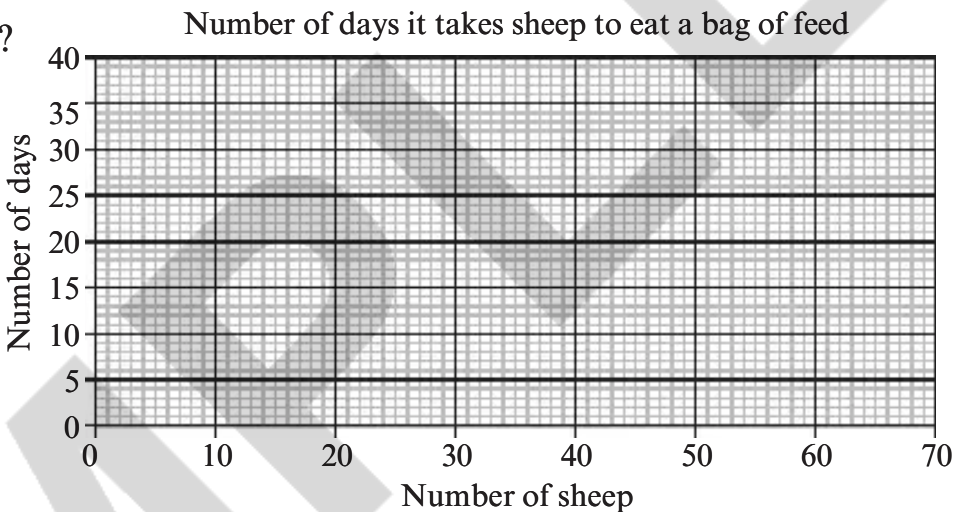
- 15 It takes 20 sheep 9 days to eat 1 bag of feed.
- Copy and complete this table.

Number of sheep (x)	5	10	15	20	30	40	60
Number of days (y)				9			
x and y				180			

- What do you notice about all of the values in the $x \times y$ row of the table?

Will this be true whatever values of x and y you choose?

- Make a copy of this coordinate grid and plot the points from your table on the grid.
 - Is it possible to draw a straight line through all the points?
 - Draw a smooth curve that goes through all your points.



- 
- iv Use your graph to estimate the number of days it takes 7 sheep to eat 1 bag of feed.
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12 ► Probability

› 12.1 Mutually exclusive events

Key words

mutually
exclusive

1 There are 12 balls in a bag. Each ball has a number. Here are the numbers:

A ball is chosen at random. Find the probability that the number is

- a** 1
b not 1
c more than 6
d an even number
e an odd number.

- 2** A runner is in a race. The probability that he will win is 0.1.

The probability that he will come second is 0.25. The probability that he will come third is 0.45.
Work out the probability that he will

- a** come first or second **b** not be in the first three.

- 3** The temperature at midday tomorrow will be higher, lower or the same as the temperature at midday today. The probability that the temperature will be higher is 15%. The probability that the temperature will be lower is 65%.

Work out the probability that the temperature will

- a** not be higher **b** not be lower **c** be the same.

Practice

- 4** There are 50 cars in a car park. 15 cars are silver, 8 cars are white and 9 cars are black. A car is chosen at random. Work out the probability that the car is

- a** black or white **b** not silver
c neither silver nor black.

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12.1 Mutually exclusive events

- 5** There are 5 colours on a spinner. This table shows the probabilities of landing on different colours.

Colour	blue	green	yellow	orange	red
Probability	0.35	0.1	0.25		

- a** Find the probability of landing on
i green or blue **ii** not blue.
b Orange and red are equally likely. Find the probability of not landing on red.

- 6** There are 12 coloured counters in a bag. The counters are black, white or grey.

A counter is chosen at random. The probability that the counter is not black is $\frac{3}{4}$. The probability that the counter is not white is $\frac{2}{3}$.

Work out the probability that the counter is grey.

Challenge

- 7** Ten letters are written on cards.

A **A** **A** **B** **C** **C** **C** **D** **S** **S**

A card is chosen at random. Work out the probability that the letter is in the word

- 8 There are 100 tickets, numbered from 1 to 100, in a box. One ticket is chosen at random. Find the probability that the ticket
- | | |
|--------------------------|---------------------------------|
| a is the number 37 | b is not 99 or 100 |
| c is an odd number | d is not a multiple of 20 |
| e is not a multiple of 9 | f does not contain the digit 6. |

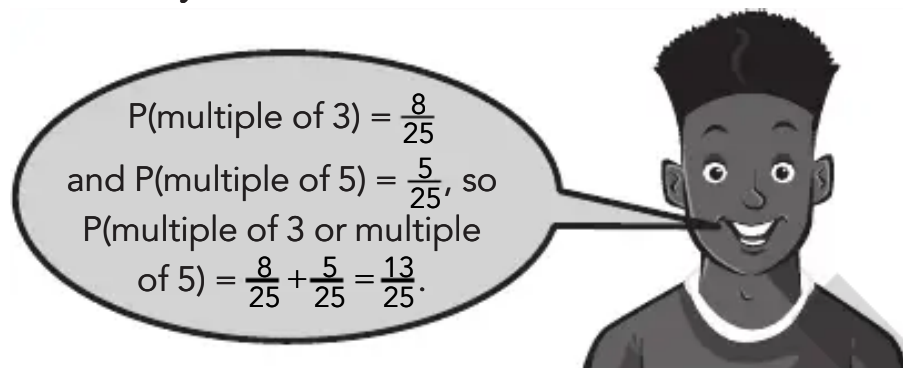
- 9 Zara rolls two fair dice and adds the scores. Here are two events.
 T = the total is a multiple of 3 F = the total is a multiple of 5
 $P(T) = \frac{1}{3}$ and $P(F) = \frac{7}{36}$
- a Show that the events T and F are **mutually exclusive**.
- b Find the probability that
- | | |
|----------------------------------|------------------------|
| i T or F happens | ii T does not happen |
| iii neither T nor F happens. | |

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12 Probability

- 10 There are 25 balls in a box, numbered from 1 to 25. A ball is chosen at random.
- a Find the probability that the number is
- | | | |
|-----------------|-------------------|--------------------------|
| i an odd number | ii an even number | iii not a multiple of 7. |
|-----------------|-------------------|--------------------------|
- b Marcus says:



What mistake has Marcus made?

> 12.2 Independent events

> Exercise 12.2

Key words

independent

- 1 You roll a red fair dice and a blue fair dice.
 - a Explain why getting an even number on the red dice and getting an odd number on the blue dice are **independent events**.
 - b Are getting an even number on the red dice and getting an even number on the blue dice independent events? Explain your answer.
 - c Explain why getting an even number on the red dice and getting an odd number on the red dice are not independent events.
 - 2 a Here are two events.
 - i There is a thunderstorm. ii Zara is late for school.

Explain how these two events could be not independent.

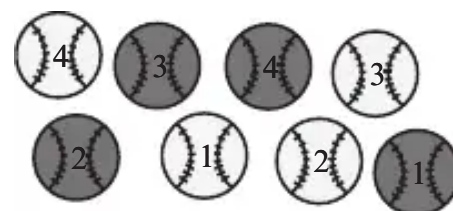
 - b Here are another two events.
- Arun is late for school on Monday. Arun is late for school on Tuesday.
- Do you think these events are independent? Give a reason for your answer.

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12.2 Independent events

- 3 There are 8 balls in a bag. Four balls are white and numbered 1 to 4. Four balls are black and numbered 1 to 4. A ball is chosen at random.
 - a Find the probability that the ball is
 - i white and 4 ii white iii 4
 - b The ball is white. What is the probability that it is 4?
 - c The ball is black. What is the probability that it is 4?
 - d Event R is ‘the ball is white’. Event F is ‘the ball is 4’. Explain why these events are independent.



Practice

- 4 a You roll a fair dice. Work out the probability that the number you get is
 - i less than 4 ii more than 2 iii a multiple of 3. - b You roll a fair dice and get an even number. Work out the probability that the number is
 - i less than 4 ii more than 2 iii a multiple of 3. - c Show that getting an even number and getting a multiple of 3 are independent events.
- 5 You roll a fair dice three times. You get a 2 each time.

Which of these statements is correct? Give a reason for your answer.

- A The probability of a 2 next time is more than $\frac{1}{6}$
- B The probability of a 2 next time is less than $\frac{1}{6}$
- C The probability of a 2 next time is $\frac{1}{6}$

- 6 The names of 3 boys and 3 girls are put in a hat. One name is chosen at random. The name is not replaced in the hat. Then a second name is chosen at random.

Event A is the first person is a girl.

Event B is the second person is a girl.

- a Show that the two events are not independent.
- b Suppose the first name is replaced before the second name is taken. Are the events independent this time? Give a reason for your answer.

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12 Probability

Challenge

- 7 In a bag, there are 8 cards with the letters A, B, C, D, E, F, G and H. One card is chosen at random.

- a The letter is in the word FACE. What is the probability that the letter is in the word BACH?
- b The letter is **not** in the word FACE. What is the probability that the letter is in the word BACH?
- c Explain why being in the word FACE and being in the word BACH are independent events.
- d Show that being in the word FACE and being in the word

- 8 **EACH are not independent events.** A black fair dice and a white fair dice are rolled. Here are three events.

X: The black dice is 6 Y: The two dice have the same number Z: the total is 12

- a Show that X and Y are independent events.
- b Show that X and Z are not independent events.

- 9 There are 6 red socks, 4 blue socks and 2 yellow socks in a drawer. One sock is taken out at random and it is red. It is not replaced. Then a second sock is taken out at random.

- a Work out the probability that the second sock is
 - i red
 - ii blue
 - iii yellow.

b Find the probability that all 3 socks are the same colour.

Exercise 12.3

Focus

- Find the probability that

- a** they both win **b** Arun loses
c Sofia loses **d** they both lose.

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12.3 Combined events

- 2** Marcus rolls a fair dice twice. Work out the probability that
- | | |
|----------------------------------|-----------------------------|
| a the first roll is 6 | b both rolls are 6 |
| c the first roll is not 6 | d neither roll is 6. |

- 3** Zara is taking a driving test. The test is in two parts: a theory test and a practical test.

$P(\text{Zara passes theory test}) = 0.7$ and $P(\text{Zara passes practical test}) = 0.6$

Work out the probability that Zara

- a** passes both tests **b** fails the theory test
c fails the theory test and passes the practical test.

Practice

- 4** A spinner has three colours, red, white and blue. $P(\text{red}) = \frac{1}{8}$ and $P(\text{white}) = \frac{1}{4}$.

The spinner is spun twice. Find the probability of landing on

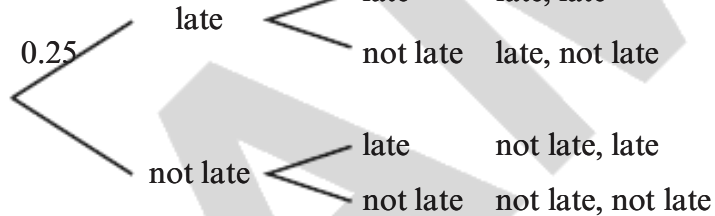
- a** red both times **b** white then red **c** red then white
d white then blue **e** blue both times.

- 5** There are two trains. The probability that the first train is late is 0.25. The probability that the second train is late is 0.4.

- a** Copy this tree diagram and write in the probabilities.

First	Second	Outcome
-------	--------	---------

0.4 late late, late



- b** Find the probability that
- i** both trains are late **ii** neither train is late **iii** at least one train is on time.

- 6** There are two boxes of red and blue pencils. A pencil is taken at random from each box.

The probability of choosing a red pencil from the first box is 0.6.

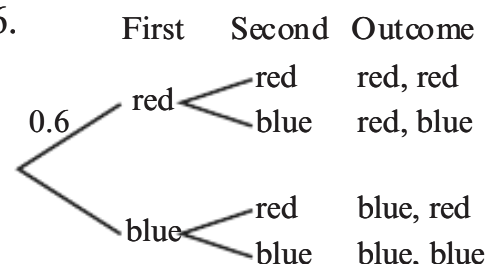
The probability of choosing a red pencil from the second

box is 0.35.

- a** Copy this tree diagram and write in the probabilities.

- b** Find the probability of choosing

- i** two red pencils **ii** no red pencils
- iii** a red pencil from the second box but not from the first.

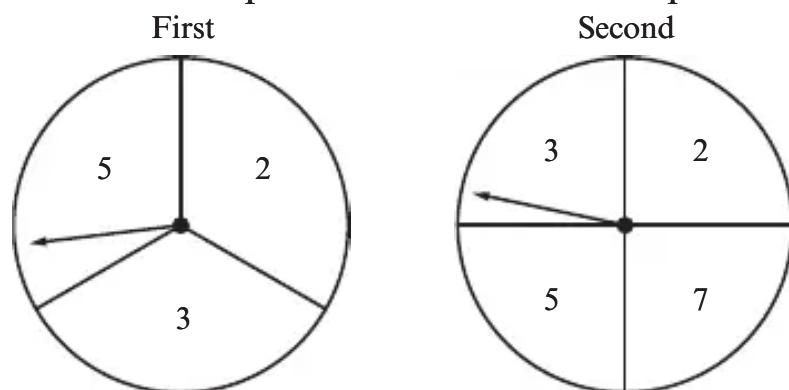


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12 Probability

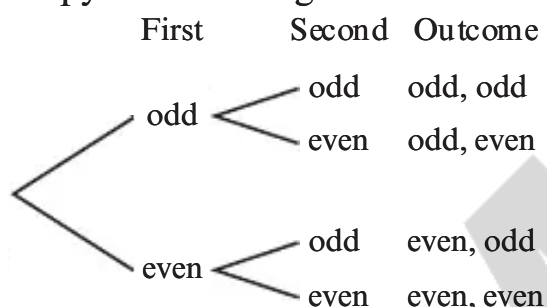
Challenge

- 7** Here are two spinners. Each sector on a spinner is equally likely.



Each spinner is spun once. You are interested in whether the numbers are odd or even.

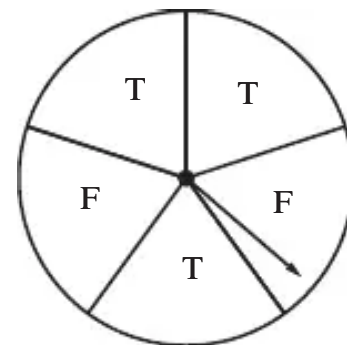
- a** Copy this tree diagram and write in the probabilities.



- b** Find the probability of

- i** two odd numbers **ii** two even numbers

- iii at least one odd number iv one odd and one even number.
- 8 This spinner can show T or F. The spinner is spun twice.
- a Draw a tree diagram to show the outcomes.
- b Find the probability of the spinner showing
- i T both times ii T at least once.



- 9 The probability that Arun passes a science exam is 0.8.
The probability that Sofia passes a history exam is 0.95.
Work out the probability that one of them passes and the other fails. Show your method.

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12.4 Chance experiments

> 12.4 Chance experiments

Exercise 12.4

Focus

Key words

relative frequency

- 1 Four coins are flipped together. The number of heads is recorded. This is repeated 50 times. The table shows the results.

Number of heads	0	1	2	3	4
Frequency	2	16	23	8	1

Work out these relative frequencies. Give your answers as decimals.

- a 2 heads b more than 2 heads c less than 2 heads

- 2 A spinner has two colours, red (R) and blue (B). Here are the results of 20 spins:

B R R R B R B R R B B B B R B B R R B B

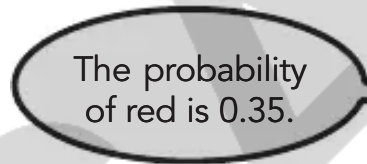
- a Work out the **relative frequency** of red.

Here are the results of another 20 spins.

B B B B R B B R R R B B B B B B B B B B

- b Work out the relative frequency of red based on all 40 spins.

- c Arun says:



Do the relative frequencies support this conjecture? Explain your answer.

- 3** A coin is flipped until it shows a head and the number of flips is recorded. This is repeated 50 times. Here are the results:

Number of flips to get a head	1	2	3	4	5	6	7	8
Frequency	29	14	3	1	0	0	2	1

Work out the relative frequency of

- a** one flip to get a head **b** 3 or more flips to get a head.

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12 Probability

Practice

- 4** A spinner is divided into 10 equal sectors. Some of the sectors are coloured green.

Here are the results of 500 spins. The table shows the frequency of landing on green after different numbers of spins.

Number of spins	25	100	200	500
Frequency of green	17	70	157	391

- a** Show that after 25 spins the relative frequency of landing on green is 0.68.
- b** Find the relative frequency of landing on green after
 - i** 100 spins
 - ii** 200 spins
 - iii** 500 spins.
- c** Estimate the number of sectors that are green. Give a reason for your answer.

- 5** Zara looks at the cars passing her school. She counts how many cars are silver. She writes down the total after every 10 cars.

Here are the results:

Total	10	20	30	40	50	60	70	80
Silver cars	2	7	11	16	19	23	27	31
Relative frequency	0.2	0.35	0.367					

- Copy the table and complete the relative frequencies.
- Draw a graph to show the changing relative frequencies.

- c** Estimate the probability of a silver car.
- 6** Marcus flips two coins. After every 20 flips he records the frequency of two heads. Here are his results:

Flips	20	40	60	80	100
Frequency of two heads	5	9	11	17	19
Relative frequency	0.25		0.183		

- a** Copy the table and complete the relative frequencies.
- b** Draw a graph to show the changing relative frequencies.

Arun carries out the same experiment. Here are his results:

Flips	20	40	60	80	100
Frequency of two heads	4	11	16	20	24
Relative frequency	0.2				0.24

- c** Copy and complete Arun's table.
- d** Plot Arun's relative frequencies on the same graph as Marcus' relative frequencies.

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12.4 Chance experiments

Challenge

- 7**
- a** Flip a coin 10 times. Work out the relative frequency of the coin landing on tails.
- b** Flip your coin another 10 times. Work out the relative frequency of the coin landing on tails for all the throws so far.
- c** Repeat this three more times so you have the results of 50 throws in total.
- d** Draw a graph to show your changing relative frequencies.
- e** Compare your relative frequencies with the probability of a coin landing on a tail.

- 8** Here are the results of 150 rolls of a dice.

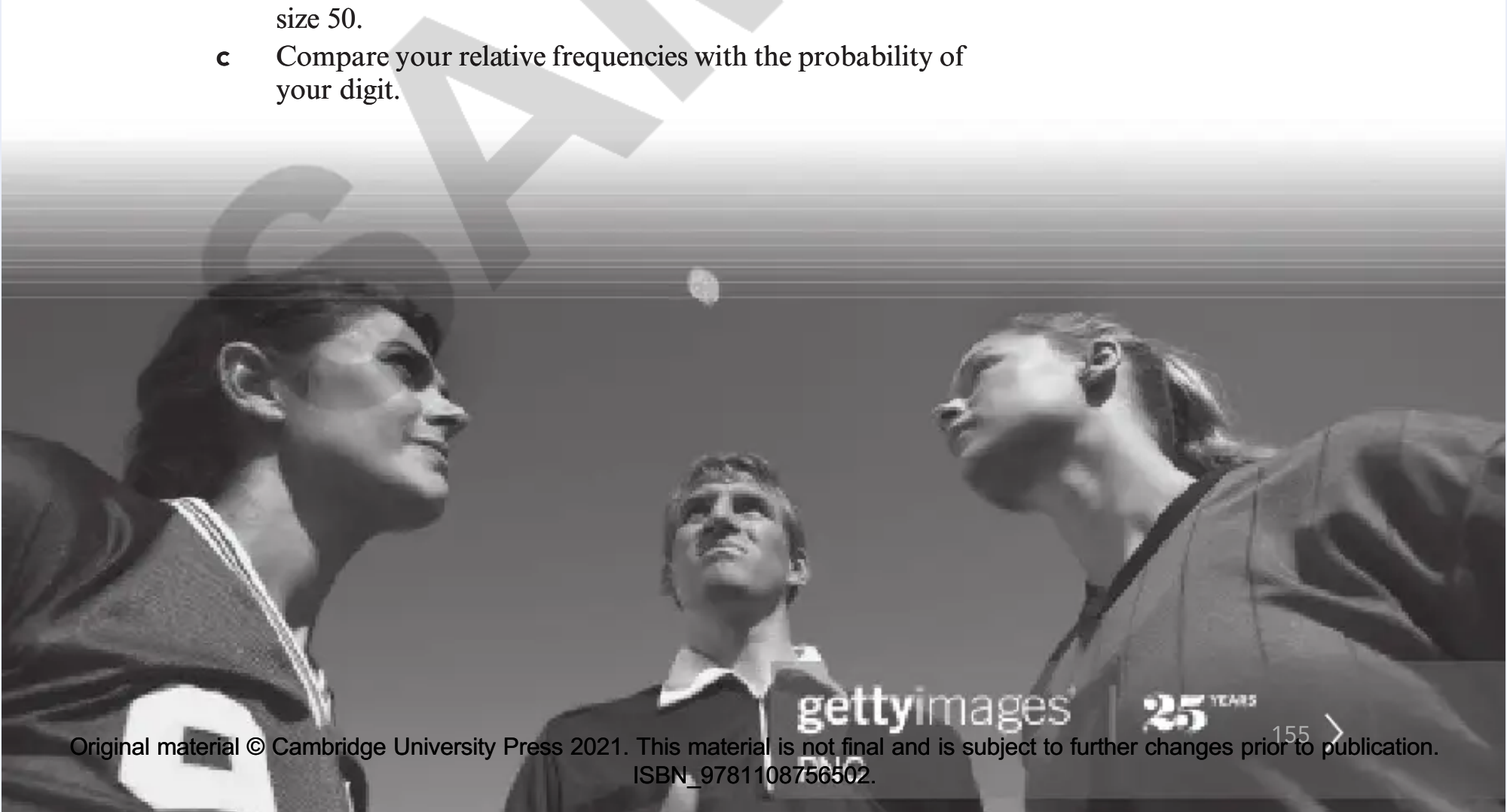
5	1	5	1	2	4	2	3	3	6	2	2	5	5	4	6	2	5	3	1	3	2	3	5	4
6	1	3	1	1	2	6	3	6	6	3	1	4	4	3	3	6	6	3	4	4	2	2	4	2
1	2	4	4	1	5	4	6	2	4	6	4	4	4	1	2	2	1	6	3	4	5	5	3	4
4	6	2	2	6	1	6	1	4	1	2	5	6	3	5	2	6	3	6	5	5	5	6	1	6
4	1	1	5	4	1	3	3	6	3	5	5	5	5	1	4	1	1	6	1	6	2	2	2	1
2	3	2	3	2	4	1	6	6	5	6	3	5	5	3	3	4	2	3	5	5	5	1	5	6

Choose one digit.

- a** Show how the relative frequency of your digit varies for samples of size 10.
- b** Find the relative frequency of your digit for a sample of

size 50.

- c Compare your relative frequencies with the probability of your digit.



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13 Position and transformation

> 13.1 Bearings and scale drawings

Exercise 13.1

Focus

- 1 A map has a scale of '1 cm represents 8 km'.
Copy and complete the calculations to work out the answers to these questions.
 - a How far in real life is 4.5 cm on the map? $4.5 \times 8 \text{ km} = \square \text{ km}$
 - b How far on the map is 18 km in real life? $18 \div 8 \text{ cm} = \square \text{ cm}$
- 2 Follow the steps to draw a scale drawing for each of these journeys.
Use a scale of 1 cm represents 10 km. Start by making a copy of the diagram

shown for each part.

- a A ship leaves a harbour and sails 60 km on a bearing of 120° .

Step 1: Put the centre of your protractor on the dot for the harbour, and line up 0° with the north arrow. Make a mark at 120° .

Step 2: Work out the distance the ship sails using the scale.
 $60 \div 10 \text{ cm} = \square \text{ cm}$

Step 3: Join the dot for the harbour with your mark for 120° with a straight line that is exactly $\square \text{ cm}$ long.

- b A ship leaves an island and sails 85 km on a bearing of 035° .

Step 1: Put the centre of your protractor on the dot for the island, and line up 0° with the north arrow. Make a mark at 35° .

Step 2: Work out the distance the ship sails using the scale.
 $85 \div 10 \text{ cm} = \square \text{ cm}$

Step 3: Join the dot for the harbour with your mark for 35° with a straight line that is exactly $\square \text{ cm}$ long.



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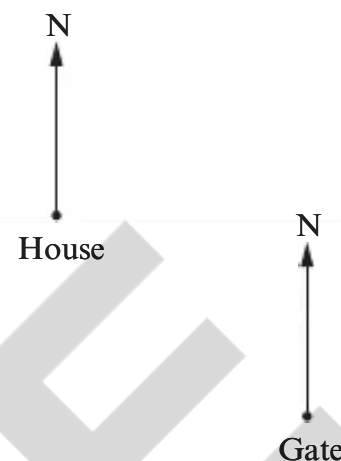
13.1 Bearings and scale drawings

- 3 Maha leaves her house and walks on a footpath for 8 km on a bearing of 095° .

Copy and complete the scale drawing to show her journey.

Use a scale of 1 cm represents 2 km.

- 4 Luca and Fabia stand by a gate. Luca walks on a bearing of 230° for 200 m. Fabia walks on a bearing of 280° for 300 m. Copy and complete the scale drawing to show their journeys. Use a scale of 1 cm represents 100 m.



Practice

- 5 Dom and Keri stand by a gate. Dom cycles on a bearing of 085° for

80 m. Keri cycles on a bearing of 145° for 60 m.

- a Show both their journeys on the same scale drawing. Use a scale of 1 cm represents 10 m.

- b On your scale drawing, measure the distance between Dom and Keri at the end of their cycle. How far apart are they in real life?

- 6 A red jeep is 50 km east of a blue jeep. The red jeep travels on a bearing of 295° . The blue jeep travels on a bearing of 107° . Could the jeeps meet? Explain your answer.

- 7 Two lighthouses are 120 km apart. Lighthouse C is south of lighthouse B.

Tip

You could start by drawing a rough sketch.

A ship is on a bearing of 305° from lighthouse C and 210° from lighthouse B.

- a Draw a scale diagram to show the position of the ship. Use a scale of 1 : 1 500 000.
- b The captain of the ship thinks he is closer to C than B. Is he correct? Justify your answer.

- 8 A ship leaves a harbour and sails 125 km on a bearing of 080° .
The ship then sails 85 km on a bearing of 145° .

- a Make a scale drawing of the ship's journey.
- b How far must the ship now sail in a straight line to return to the harbour?
- c On what bearing must the ship now sail to return to the harbour?

Tip

Use a scale of
1 cm to represent
10 km.

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13 Position and transformation

- 9 An aeroplane leaves an airport and flies 240 km on a bearing of 300° .
The aeroplane then changes direction and flies 120 km on a bearing of 190° .

- a Make a scale drawing of the aeroplane's journey.
- b How far must the aeroplane now fly in a straight line to return to the airport?
- c On what bearing must the aeroplane now fly to return to the airport?

Tip

Use a scale of
1 cm to represent
20 km.

- 10 Greg leaves his car and walks 16 km on a bearing of 095° .
He then changes direction and walks 14 km on a bearing of 035° .

- a Make a scale drawing of Greg's walk.
- b How far must Greg now walk in a straight line to return to his car?
- c On what bearing must Greg now walk to return to his car?

Tip

Use a scale of
1 cm to represent
2 km.

Challenge

- 11 Li lives 10 km west of Chul. Li leaves home and walks 8 km to a farm. He walks on a bearing of 137° . Chul leaves home and walks to meet Li at the farm.
How far, and on what bearing, does Chul walk?

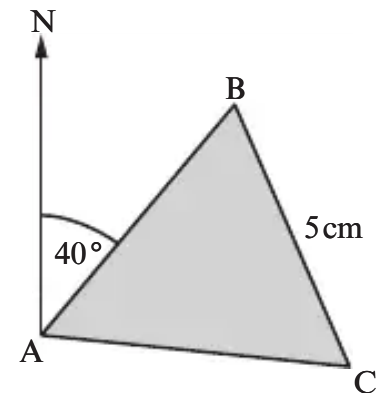
- 12 A lighthouse is 75 km east of a port. The captain of a ship knows

12 A lighthouse is 7.5 km from a port. The captain of a ship knows he is on a bearing of 052° from the port.

- How far is the ship from the lighthouse?
- How far is the ship from the port?

13 The sketch shows an equilateral triangle ABC of side length 5 cm. The bearing of B from A is 040° .

- Work out the bearing of C from B. Explain how you worked out your answer.
- Work out the bearing of A from C. Explain how you worked out your answer.
- Make an accurate copy of the sketch. Use your sketch to check your answers to parts **a** and **b** are correct.



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13.1 Bearings and scale drawings

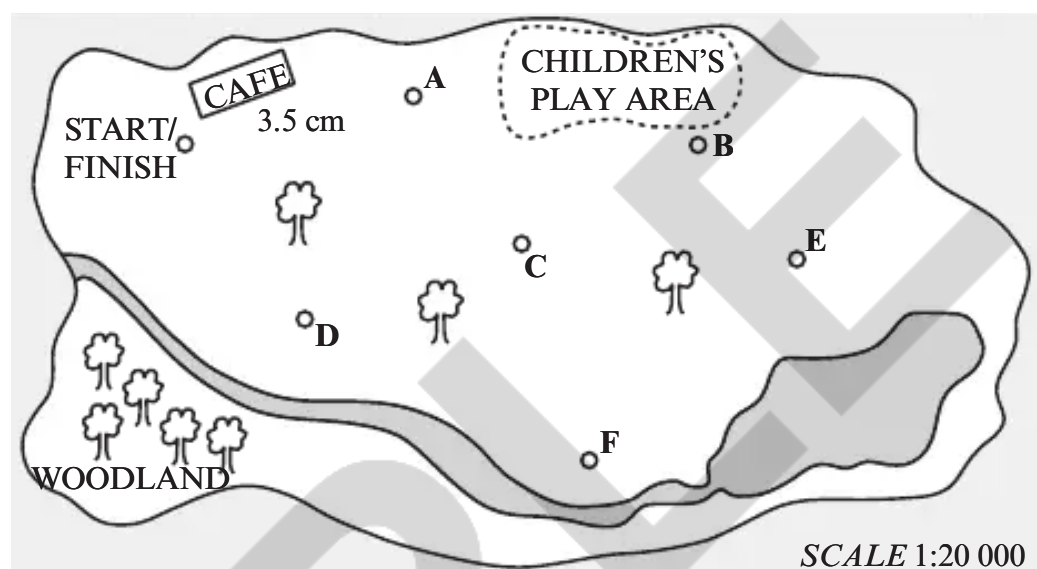
14 A boat sails 120 km from a port on a bearing of 075° . The boat then changes direction and sails 100 km on a bearing of 145° . Finally the boat sails 150 km on a bearing of 260° .

How far and on what bearing must the boat sail to return to port?

15 In a competition, you have a map and a compass. The map shows a start/finish point and six markers labelled A to F. The scale of the map is 1:20 000.

You must visit every

marker on the map by using a bearing from one marker to the next. You can visit the markers in any order. The winner is the quickest person to finish.

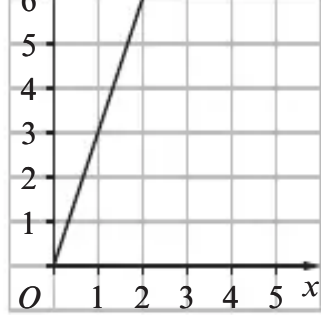


- Choose a route from the start to the finish that visits every marker.
- Copy and complete the table. What is the total distance in real life of your route?

From	To	Bearing	Distance on map (cm)	Distance in real life (m)
Start				

SA

$\left(\frac{1}{4} \times 1, \frac{1}{4} \times 12 \right) = (\square, \square)$



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13.2 Points on a line segment

- 3 The diagram shows the line segment OC. Cards **H** to **M** show the fraction of the way along OC. Cards **i** to **vi** show coordinates.

Match each card **H** to **M** with the correct card **i** to **vi**. The first one has been done for you: **H** and **iii**.

H $\frac{1}{8}$

I $\frac{1}{4}$

J $\frac{3}{4}$

K $\frac{1}{2}$

L $\frac{5}{8}$

M $\frac{3}{8}$

i (12, 12)

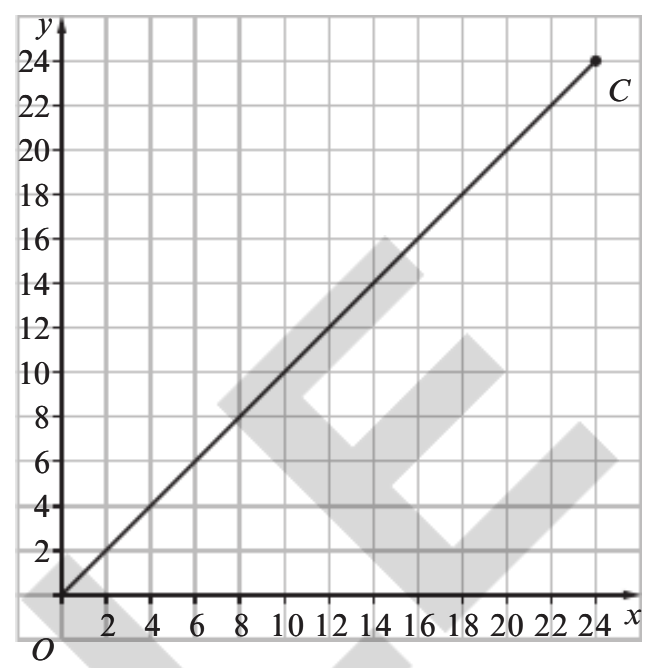
ii (6, 6)

iii (3, 3)

iv (9, 9)

v (15, 15)

vi (18, 18)



- 4 The diagram shows the points O (0, 0), A (3, 4) and B (6, 8). Points A and B are equally spaced along a straight line such that the distance OA is equal to the distance AB.

The points continue along the line, equally spaced. Each point is labelled with a letter of the alphabet, in order from A to Z.

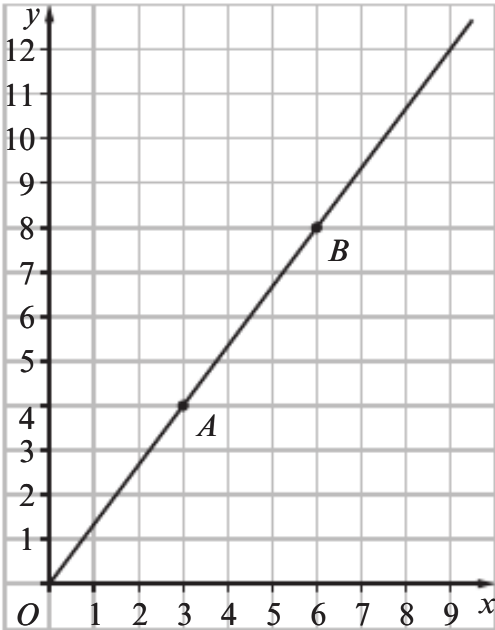
- a Use the diagram to work out the position of point C. Write the coordinates of C.
- b Copy and complete this table.

Letter	A	B	C	D	E	F	K	R	W
position in alphabet	1st	2nd	3rd	4th	5th	6th	11th	18th	23rd
x-coordinate	$1 \times 3 = 3$	$2 \times 3 = 6$							
y-coordinate	$1 \times 4 = 4$	$2 \times 4 = 8$							

coordinate pair	(3, 4)	(6, 8)							
-----------------	--------	--------	--	--	--	--	--	--	--

c Copy and complete these statements.

- i The x -coordinates are the numbers in the times table. To work out the x -coordinate of any letter, multiply the position number of the letter in the alphabet by .
- ii The y -coordinates are the numbers in the times table. To work out the y -coordinate of any letter, multiply the position number of the letter in the alphabet by .



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13 Position and transformation

Practice

5 O is the point (0, 0), G is (20, 25) and H is (18, 12). Write whether **A**, **B** or **C** is the correct answer in each case.

- a $\frac{1}{5}$ of the way along OG is **A** (5, 4) **B** (4, 5) **C** (5, 5)
- b $\frac{3}{5}$ of the way along OG is **A** (15, 12) **B** (16, 20) **C** (12, 15)
- c $\frac{1}{6}$ of the way along OH is **A** (3, 2) **B** (9, 6) **C** (2, 3)
- d $\frac{5}{6}$ of the way along OH is **A** (15, 9) **B** (9, 10) **C** (15, 10)

- 6 O is the point (0, 0) and A is the point (5, 8). Points A and B are equally spaced along the same line such that the distance OA is equal to the distance AB.
- a What are the coordinates of point B?
- b C is the next point along the same line such that distance BC is equal to distances OA and AB. What are the coordinates of point C?
- c The points continue along the line, equally spaced. Each point is labelled with a letter of the alphabet, in order from A to Z. Show that point E has coordinates (25, 40).
- d What are the coordinates of point T? Show how you worked out your answer.
- e Write an expression for the coordinates of the n th letter of the alphabet along this same line.

Tip

You could draw a diagram to help.

E is the 5th letter in the alphabet.

T is the 20th letter in the alphabet.

You could write your expression as: n th letter is (,).

- 7 O is the point (0, 0) and J is the point (42, 54). Points E, F, G, H and I are equally spaced along the line OJ. Work out the coordinates of H.
- 8 C is the point (1, 1) and D is the point (10, 13). E is the point that lies $\frac{1}{3}$ of the way along CD. Show that E has coordinates (4, 5).
- 9 F is the point (2, 3) and G is the point (7, 18). H is the point that lies $\frac{2}{5}$ of the way along FG.
- Work out the coordinates of H.
 - Check your answer is correct by drawing a diagram.

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13.2 Points on a line segment

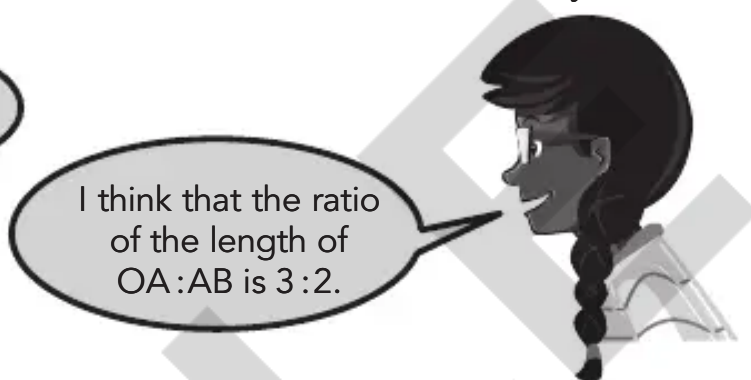
Challenge

- 10 O is the point (0, 0) and A is the point (8, 10). A lies $\frac{2}{3}$ of the way along the line segment OB.

Arun says:



Zara says:



- Is Arun correct? Justify your answer.
 - Is Zara correct? Justify your answer.
- 11 Four points on a coordinate grid are A (2, 7), B (10, 3), C (5, 3) and D (11, 5).
- Draw line segments AB and CD on a coordinate grid.
 - Point E is where line segments AB and CD cross. Write the coordinates of E.
 - Show, using calculations, that E is the midpoint of CD.
 - Show, using calculations, that E lies $\frac{3}{4}$ of the way along AB.
- 12 K is the point (−9, −12) and L is the point (−4, −2). Work out the coordinates of the point that lies $\frac{3}{5}$ of the way along KL.

13 P is the point $(-4, -7)$ and V is the point $(2, 5)$.

Points Q, R, S, T and U are equally spaced along the line PV.

- Which point along the line is the only point to have the same x and y coordinate? Show all your working.
- Which point along the line is the only point to lie on one of the axes? Show all your working.

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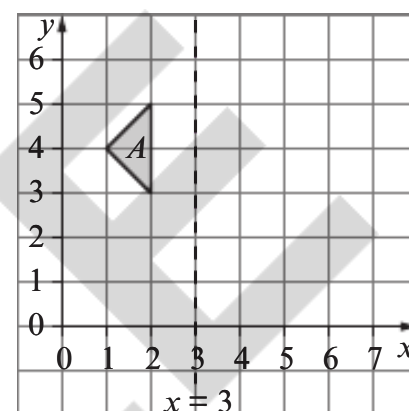
13 Position and transformation

13.3 Transformations

Exercise 13.3

Focus

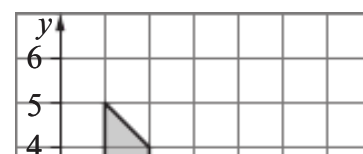
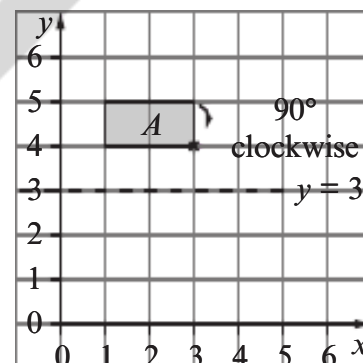
- The diagram shows triangle A. Copy the diagram.
 - Reflect triangle A in the mirror line $x = 3$. Label the image B.
 - Translate triangle B using the column vector $\begin{pmatrix} 2 \\ -1 \end{pmatrix}$. Label the image C.



Tip

$\begin{pmatrix} 2 \\ -1 \end{pmatrix}$ means 2 squares right and 1 square down.

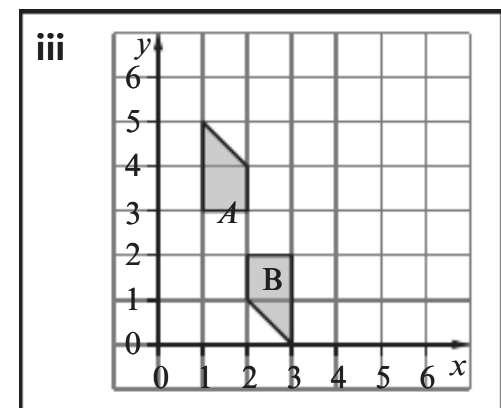
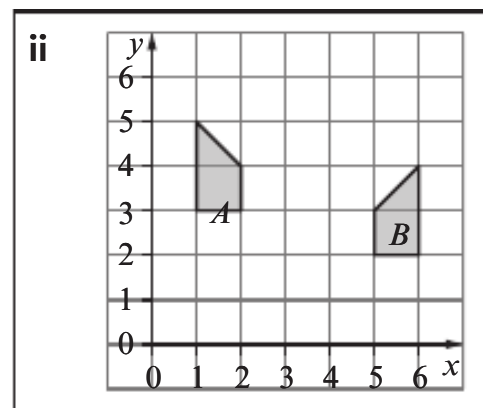
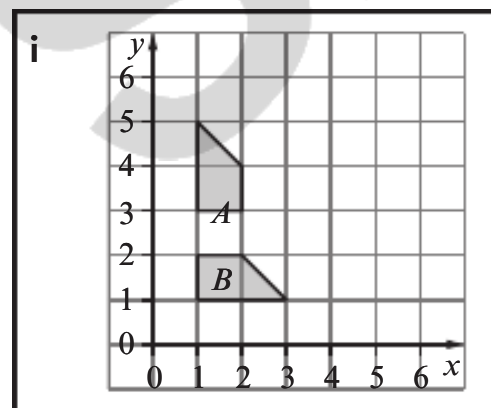
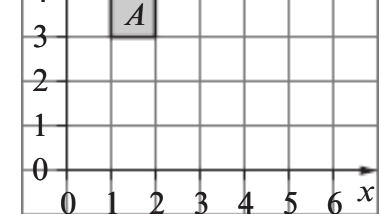
- The diagram shows rectangle A. Copy the diagram.
 - Rotate rectangle A 90° clockwise, centre $(3, 4)$. Label the image B.
 - Reflect rectangle B in the mirror line $y = 3$. Label the image C.
- The diagram shows shape A. Cards **a**, **b** and **c** show three combinations of transformations. Diagrams **i**, **ii** and **iii** show shape A and its image, shape B. Match each card **a** to **c** with the correct diagram, **i** to **iii**.



a Reflection in the line $x = 3$ followed by a translation $\begin{pmatrix} 1 \\ -1 \end{pmatrix}$.

b Rotation of 180° , centre $(3, 3)$, followed by a translation $\begin{pmatrix} -2 \\ -1 \end{pmatrix}$.

c Rotation of 90° clockwise, centre $(1, 3)$, followed by a reflection in the line $y = 2$.



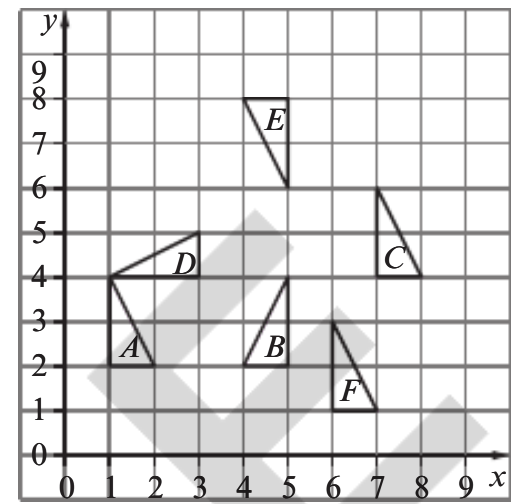
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13.3 Transformations

4 The diagram shows triangles A to F. Copy and complete these transformations.

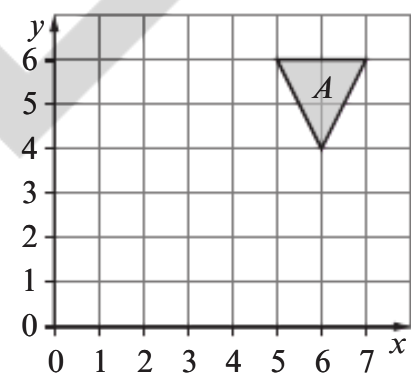
- a** A to B is a reflection in the mirror line $x = \square$
- b** A to C is a translation $\begin{pmatrix} \square \\ \square \end{pmatrix}$
- c** A to D is a rotation \square° anticlockwise, centre (\square, \square)
- d** B to E is a reflection in the mirror line $y = \square$
- e** E to C is a rotation \square° , centre (\square, \square)
- f** C to F is a translation $\begin{pmatrix} \square \\ \square \end{pmatrix}$



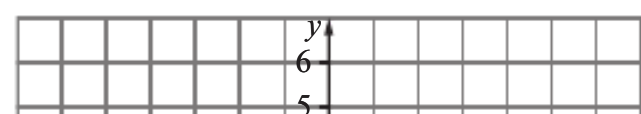
Practice

5 Copy the diagram. Draw the image of A after each combination of transformations.

- a** A translation $\begin{pmatrix} -4 \\ 1 \end{pmatrix}$ followed by a reflection in the line $y = 4$. Label this image B.
- b** A rotation of 90° anticlockwise, centre $(5, 4)$, followed by a translation $\begin{pmatrix} 0 \\ -3 \end{pmatrix}$. Label this image C.
- c** A reflection in the line $x = 5$ followed by a rotation of 180° , centre $(5, 3)$. Label this image D.

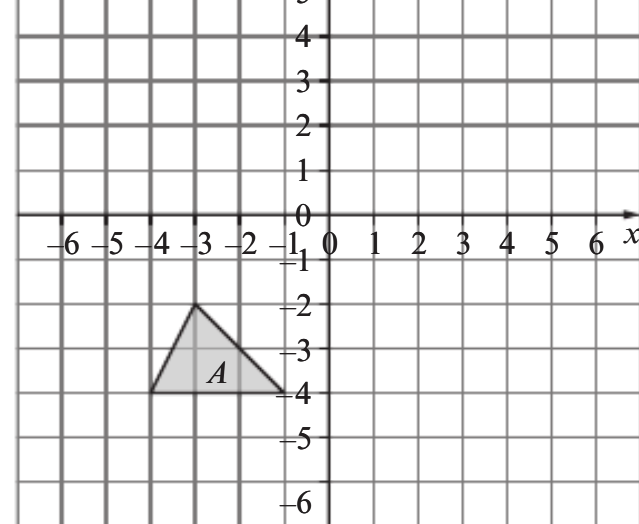


6 The diagram shows triangle A on a coordinate grid. Copy the grid.



On your diagram, draw the image of A after each combination of transformations.

- A reflection in the y -axis followed by the translation $\begin{pmatrix} 2 \\ 1 \end{pmatrix}$.
- A rotation of 180° , centre $(-2, -2)$, followed by a reflection in the x -axis.
- A translation $\begin{pmatrix} -2 \\ 6 \end{pmatrix}$, followed by a rotation of 90° anticlockwise, centre $(-3, 5)$.
- A translation $\begin{pmatrix} 6 \\ 7 \end{pmatrix}$, followed by a reflection in the line $x = 4$.



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13 Position and transformation

7 This is part of Rhian's homework:

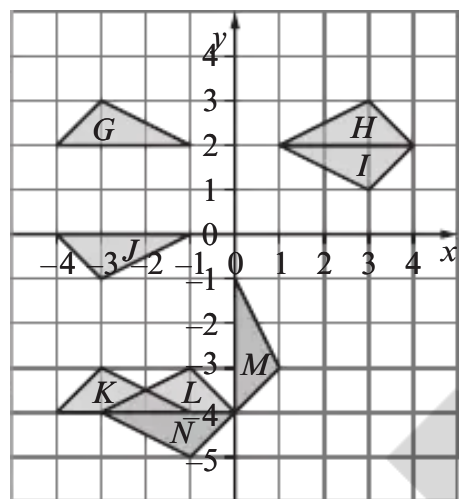
Fill in the missing words in these statements.

When you compare an object and its image after any single or combined transformation:

- corresponding lengths are *different*
- corresponding angles are *the same*
- the object and the image are *not congruent*

Is Rhian's homework correct? Explain your answer.

8 The diagram shows shapes G, H, I, J, K, L, M and N.



Describe the transformation that transforms

- shape N to shape I
- shape G to shape K

- c shape H to shape L
- e shape H to shape G
- g shape L to shape K
- i shape J to shape M
- d shape G to shape J
- f shape J to shape K
- h shape L to shape M
- j shape G to shape I.

Tip

For a **translation** you need to give the **column vector**.
 For a **reflection** you need to give the equation of the **mirror line**.
 For a **rotation** you need to give the **centre** and the **angle** and **direction** of the rotation.

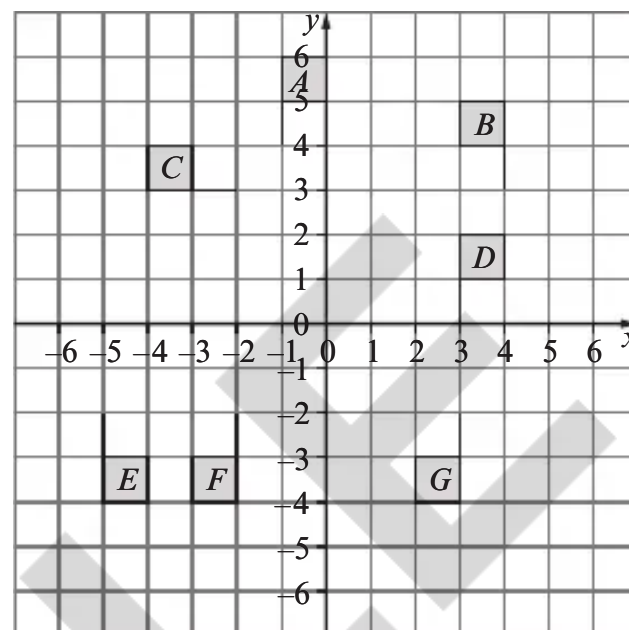
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13.3 Transformations

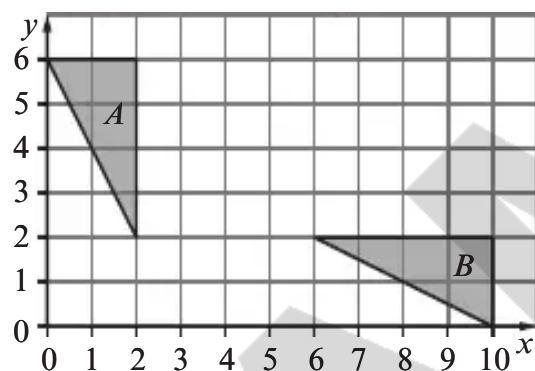
- 9 The diagram shows shapes A, B, C, D, E, F and G on a coordinate grid.

- a Describe the single transformation that transforms
- i shape A to shape C
 - ii shape A to shape D
 - iii shape E to shape G
 - iv shape E to shape F.
- b Describe a combined transformation that transforms
- i shape C to shape F
 - ii shape D to shape B.



Challenge

- 10 Zara and Arun are discussing this diagram. It shows two shapes, A and B.



Zara says:



I can transform shape A to shape B by reflecting it in the line $x = 3$ and then rotating it 90° clockwise, centre $(4, 2)$.

Arun says:



I can transform shape A to shape B by rotating it 90° anticlockwise, centre $(4, 4)$, then reflecting it in the line $x = 6$.

Is either of them correct? Draw diagrams to explain how you worked out your answer.

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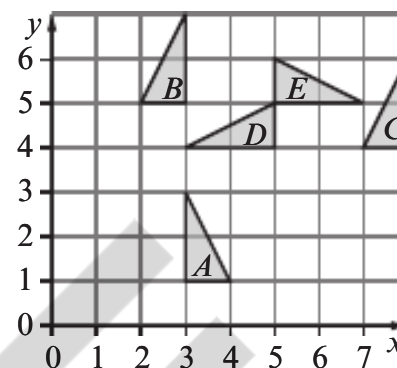
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13 Position and transformation

11 The diagram shows five triangles, A, B, C, D and E.

Look at the following combinations of transformations. Name the object triangle and the image triangle for each transformation.

- A reflection in the line $x = 4$, followed by a translation $\begin{pmatrix} 3 \\ 3 \end{pmatrix}$.
- A rotation 180° , centre $(3, 3)$, followed by a reflection in the line $y = 5$.
- A translation $\begin{pmatrix} -2 \\ -1 \end{pmatrix}$, followed by a rotation 90° anticlockwise, centre $(1, 4)$.
- A rotation 90° clockwise, centre $(3, 5)$, followed by a translation $\begin{pmatrix} 2 \\ 0 \end{pmatrix}$.

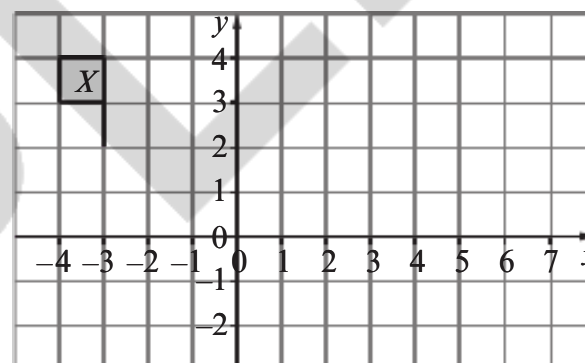


12 The diagram shows shape X. Make a copy of

the diagram.

- Draw the image of X after a reflection in the line $x = -2$, followed by a rotation of 90° clockwise about the point $(-1, 0)$, followed by a translation $\begin{pmatrix} 4 \\ 3 \end{pmatrix}$, followed by a reflection in the line $y = 1$, followed by a rotation of 90° anticlockwise about the point $(5, -1)$. Label the image Y.

- Describe the single transformation that takes Y to X.



> 13.4 Enlarging shapes

An **enlargement** of a shape is a copy of the shape that is bigger than the original. You enlarge a shape using a **scale factor** and a **centre of enlargement**.

Exercise 13.4

Focus

- 1 Copy and complete these enlargements using a scale factor of 2 and the centre of enlargement marked with an \times . One side of each triangle has been drawn for you.

Follow these steps:

Step 1: Count the number of squares from the centre of enlargement to the nearest corner of the triangle. Multiply this number by 2 to find the new distance from the centre of enlargement. Plot this point.



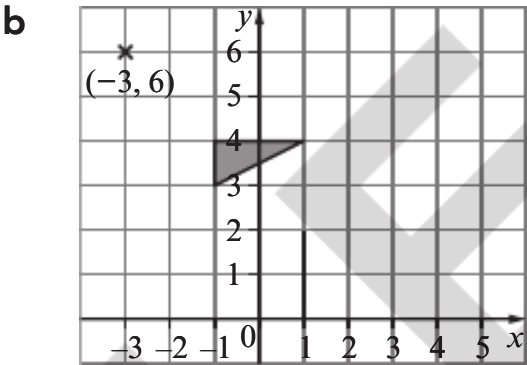
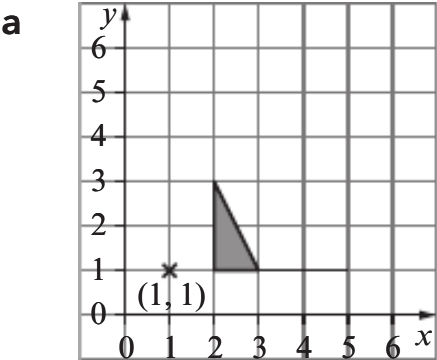
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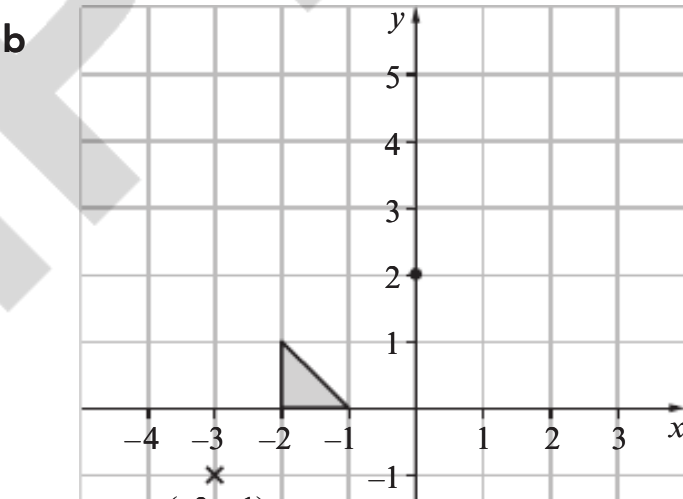
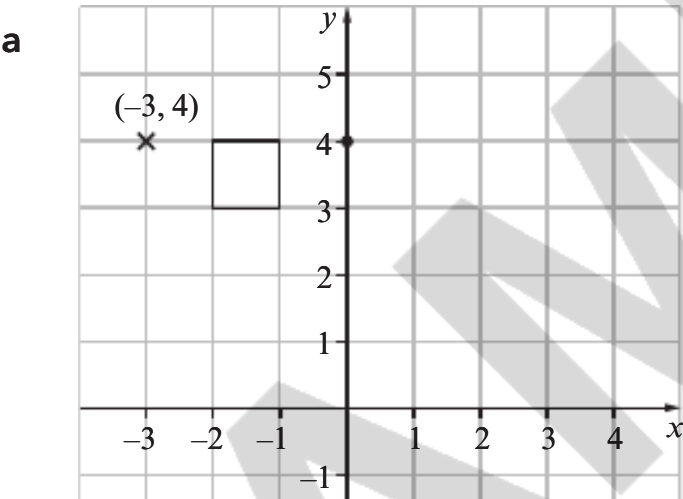
13.4 Enlarging shapes

Step 2: Count the length and height, in squares, of the triangle.

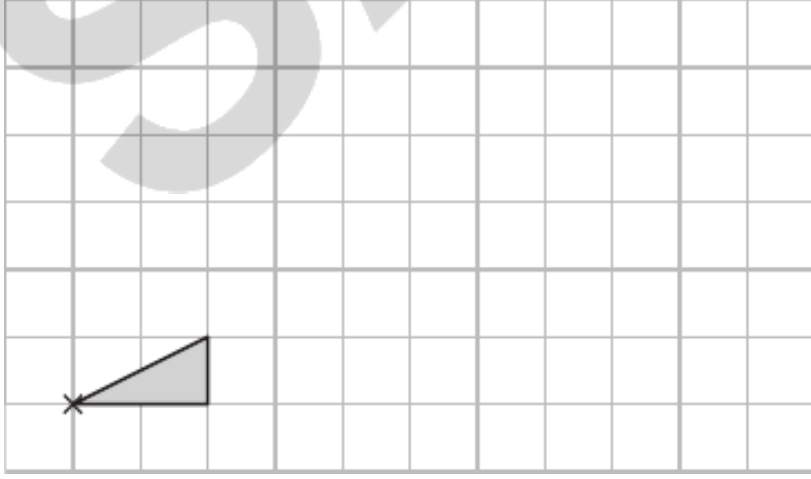
Multiply both dimensions by 2 to find the new length and height. Draw the enlarged triangle from the corner you have already plotted.



- 2 Copy and complete these enlargements using a scale factor of 3 and the centre of enlargement given. In each diagram, \times marks the position of the centre of enlargement. The dot shows the position of one of the corners of the enlarged shape.



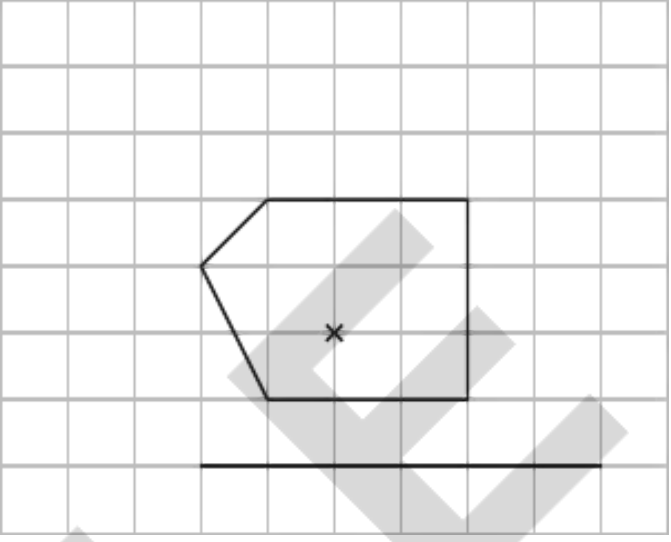
- 3 Copy and complete this enlargement with scale factor 4 and centre of enlargement shown.



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13 Position and transformation

- 4 Copy and complete this enlargement with scale factor 2 and centre of enlargement shown.



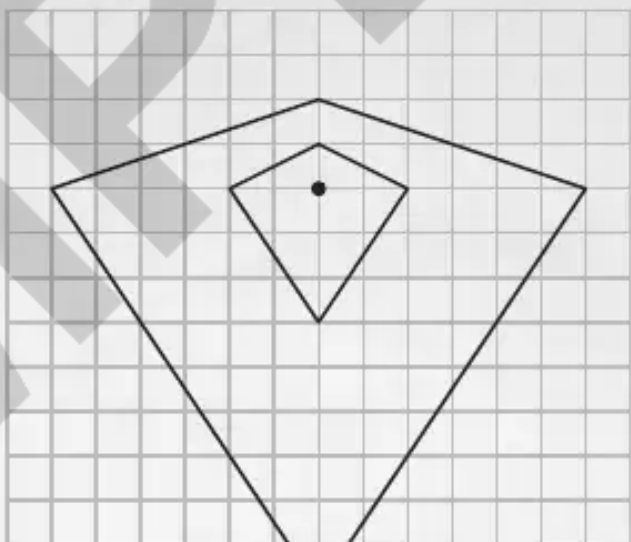
- 5 This is part of Kurt's homework:

Question

Enlarge this kite using a scale factor of 3 and centre of enlargement shown.



Answer



- a Explain the mistake Kurt has made.
- b Make a copy of the kite on squared paper. Draw the correct enlargement.

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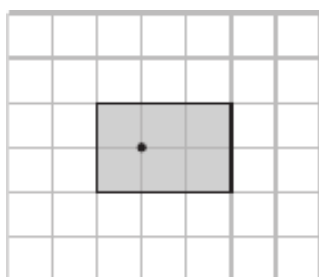
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13.4 Enlarging shapes

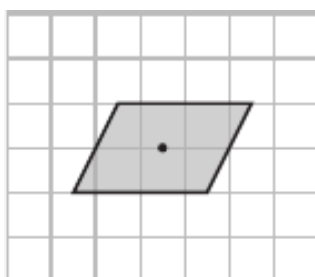
Practice

- 6 Copy each of these shapes onto squared paper. Enlarge each shape using the given scale factor and centre of enlargement.

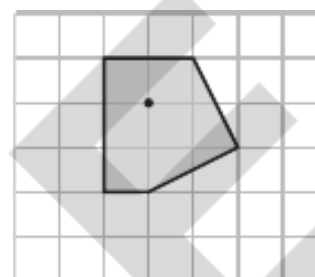
a scale factor 2



b scale factor 3

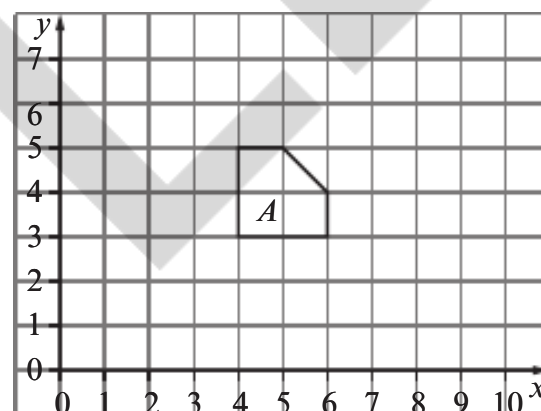


c scale factor 2



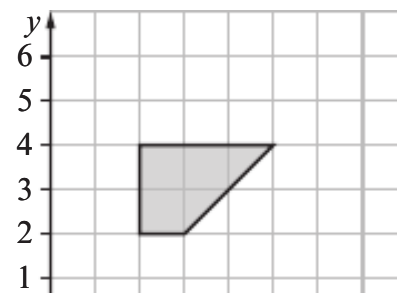
- 7 The diagram shows shape A on a coordinate grid. Make three copies of the diagram on squared paper.

- a On the first copy, draw an enlargement of the shape with scale factor 2, centre (2, 6). Label the image B.
- b On the second copy, draw an enlargement of the shape with scale factor 3, centre (6, 4). Label the image C.
- c On the third copy, draw an enlargement of the shape with scale factor 4, centre (5, 4). Label the image D.



- 8 The vertices of this trapezium are at (2, 2), (3, 2), (5, 4) and (2, 4).

- a Copy the diagram onto squared paper. Mark with a dot the centre of enlargement at (3, 3). Enlarge the trapezium with scale factor 2 from the centre of enlargement.
- b Write the coordinates of the vertices of the image.

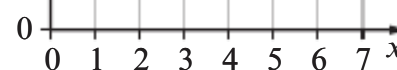


- 9 A square, M, has perimeter 12 cm and area 9 cm^2 . The square is enlarged by a scale factor of 4 to become square N. Copy and complete the working to find the perimeter and area of square N.

Perimeter of M = 12 cm \rightarrow Perimeter of N = $12 \times 4 = \square$ cm

Area of M = 9 cm^2 \rightarrow Area of N = $9 \times 4^2 = \square \text{ cm}^2$

- 10 A trapezium, W, has perimeter 18 cm and area 18 cm^2 . The trapezium is enlarged by a scale factor of 2 to become trapezium Z. Work out the perimeter and the area of trapezium Z.

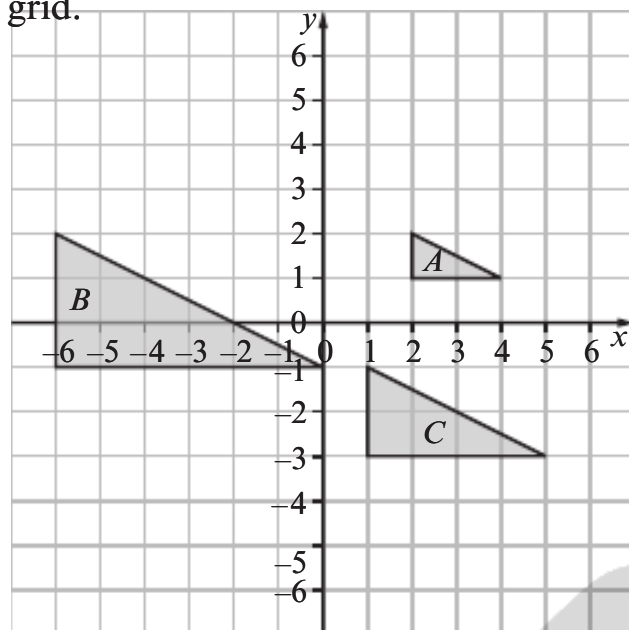


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13 Position and transformation

- 11 The diagram shows three triangles, A, B and C, on a coordinate grid.



- Triangle B is an enlargement of triangle A. Describe the enlargement.
- Triangle C is an enlargement of triangle A. Describe the enlargement.

Tip

Remember: to describe an enlargement, you need to write 'enlargement' and give the scale factor and the centre of enlargement.

Challenge

- 12 The vertices of rectangle P are at (0, -2), (-6, -2), (-6, 1) and (0, 1). The vertices of rectangle Q are at (4, 0), (2, 0), (2, 1) and (4, 1). Rectangle P is an enlargement of rectangle Q. Describe the enlargement.

- 13 The vertices of shape C are at (1, 1), (4, 1), (4, 6) and (1, 3).

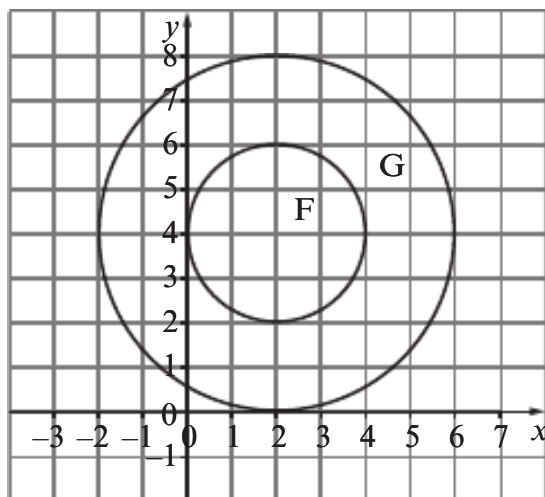
- 13 The vertices of shape C are at (1, 1), (4, 1), (4, 6) and (1, 5).
The vertices of shape D are at (−1, −2), (−1, 2), (5, −2) and (5, 8).
Shape D is an enlargement of shape C. Describe the enlargement.

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13.4 Enlarging shapes

- 14 The diagram shows two circles, F and G.



- Circle G is an enlargement of circle F. Describe the enlargement.
- Circle F has radius 2 cm. Use the formula $C = \pi d$ to work out the circumference of circle F.
- Use the scale factor of the enlargement and your answer to **b** to work out the circumference of circle G.
- Check your answer to **c** is correct by using the formula $C = \pi d$ to work out the circumference of circle G.
- Use the formula $A = \pi r^2$ to work out the area of circle F.
- Use the scale factor of the enlargement and your answer to **e** to work out the area of circle G.
- Check your answer to **f** is correct by using the formula $A = \pi r^2$ to work out the area of circle G.

- 15 Triangle H is an enlargement of triangle K by a scale factor of 3.

Triangle H has perimeter 36 cm and area 54 cm^2 .

- a** Arun works out that the perimeter of triangle K is 108 cm. Is Arun correct? Show working to justify your answer.
- b** Work out the area of triangle K. Show working to justify your answer.

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14 Volume, surface area and symmetry

> 14.1 Calculating the volume

of prisms

You can work out the volume of a prism using the formula:

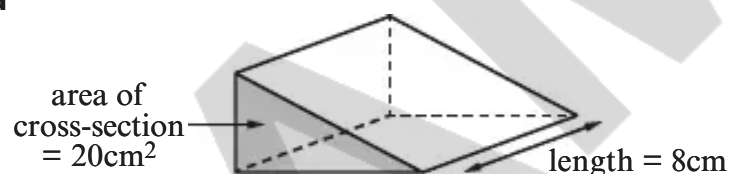
$$\text{volume} = \text{area of cross-section} \times \text{length}$$

Exercise 14.1

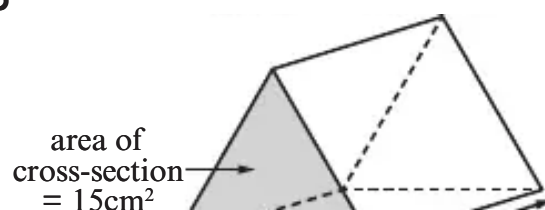
Focus

- 1 Copy and complete the workings to find the volume of each prism.

a

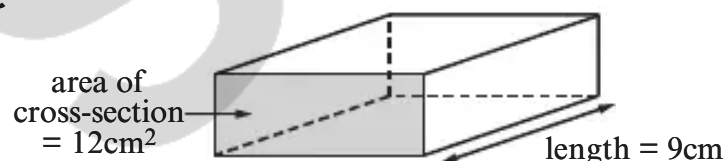


b



$$\begin{aligned}\text{Volume} &= \text{area of cross-section} \times \text{length} \\ &= 20 \times 8 = \square \text{ cm}^3\end{aligned}$$

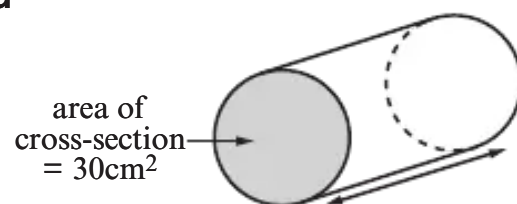
c



$$\begin{aligned}\text{Volume} &= \text{area of cross-section} \times \text{length} \\ &= \square \times \square = \square \text{ cm}^3\end{aligned}$$

$$\begin{aligned}\text{Volume} &= \text{area of cross-section} \times \text{length} \\ &= \square \times \square = \square \text{ cm}^3\end{aligned}$$

d



$$\begin{aligned}\text{Volume} &= \text{area of cross-section} \times \text{length} \\ &= \square \times \square = \square \text{ cm}^3\end{aligned}$$

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14.1 Calculating the volume of prisms

2 Copy and complete the workings to find the volume of each prism.

Tip

In these prisms, you need to work out the area of the cross-section first, then work out the volume.

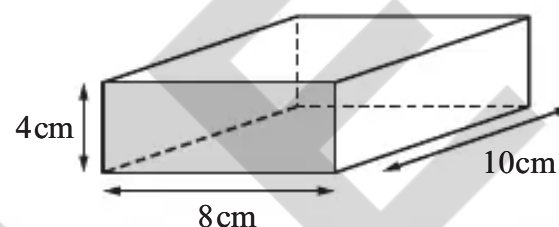
a Area of cross-section = area of rectangle

$$= \text{base} \times \text{height} = 8 \times 4 = \square \text{ cm}^2$$

Volume

$$= \text{area of cross-section} \times \text{length}$$

$$= \square \times 10 = \square \text{ cm}^3$$



b Area of cross-section = area of triangle

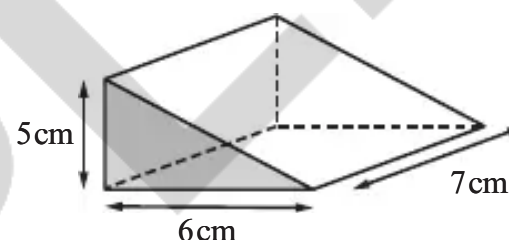
$$= \frac{1}{2} \times \text{base} \times \text{height}$$

$$= \frac{1}{2} \times 6 \times 5 = \square \text{ cm}^2$$

Volume

$$= \text{area of cross-section} \times \text{length}$$

$$= \square \times 7 = \square \text{ cm}^3$$



c Area of cross-section

= area of circle

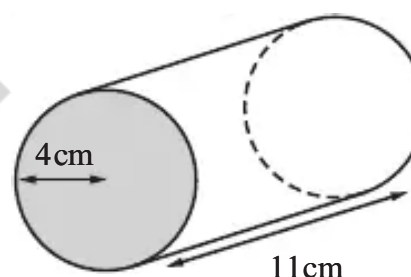
$$= \pi \times r^2 = \pi \times \square^2$$

$$= \pi \times \square = \square \text{ cm}^2$$

Volume

$$= \text{area of cross-section} \times \text{length}$$

$$= \square \times 11 = \square \text{ cm}^3$$



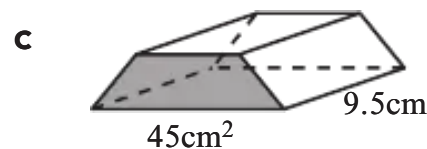
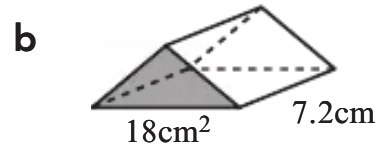
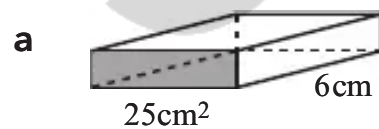
Tip

For part c of Question 1, use the 'π' button on your

calculator. Round your answer to 2 decimal places.

Practice

- 3 Work out the volume of each prism. The area of the cross-section is given.



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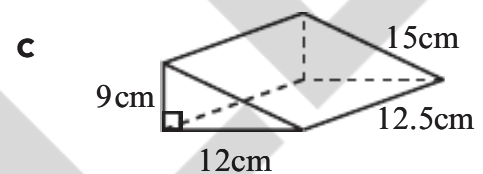
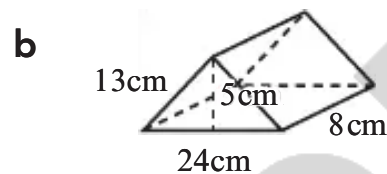
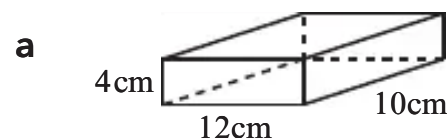
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14 Volume, surface area and symmetry

- 4 Copy and complete this table.

	Area of cross-section	Length of prism	Volume of prism
a	8.4 cm ²	20 cm	<input type="text"/> cm ³
b	24 cm ²	<input type="text"/> cm	156 cm ³
c	<input type="text"/> m ²	5.7 m	330.6 m ³
d	56.85 mm ²	<input type="text"/> mm	3524.7 mm ³

- 5 Work out the volume of each prism.



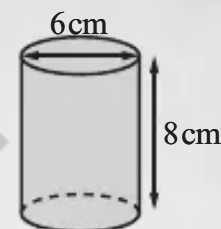
- 6 This is part of Timo's homework:

Question

Work out the volume of this cylinder.

Answer

$$V = \pi r^2 h = \pi \times 6^2 \times 8 = \pi \times 36 \times 8 \\ = 905 \text{ cm}^3 \text{ (3 s.f.)}$$

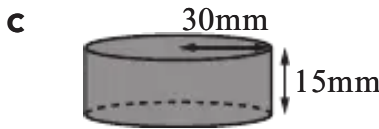
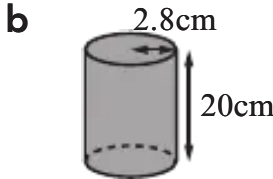
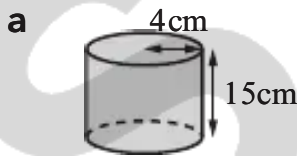


Timo has made a mistake in his solution.

Explain the mistake that Timo has made and work out the correct answer.

- 7 Work out the volume of each cylinder. Give your answers correct

to one decimal place (1 d.p.).



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14.1 Calculating the volume of prisms

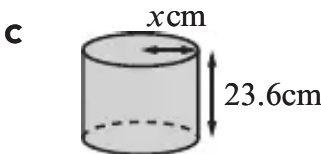
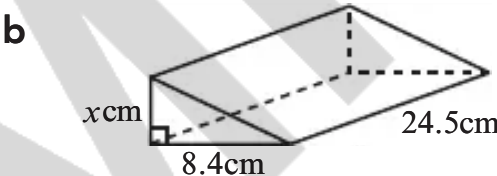
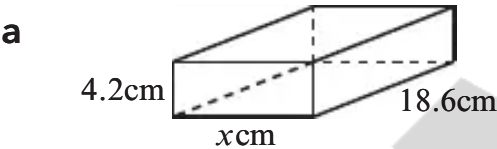
Challenge

8 Copy and complete this table. Give your answers correct to two decimal places (2 d.p.).

	Radius of circle	Area of circle	Height of cylinder	Volume of cylinder
a	7 cm	<input type="text"/> cm ²	12 cm	<input type="text"/> cm ³
b	1.5 m	<input type="text"/> m ²	2.4 m	<input type="text"/> m ³
c	9 cm	<input type="text"/> cm ²	<input type="text"/> cm	1910 cm ³
d	<input type="text"/> m	15 m ²	3.8 m	<input type="text"/> m ³
e	<input type="text"/> mm	<input type="text"/> mm ²	22 mm	1430 mm ³

9 Each of these prisms has a volume of 335 cm³. Work out the value of x in each diagram.

Give your answers correct to one decimal place (1 d.p.).

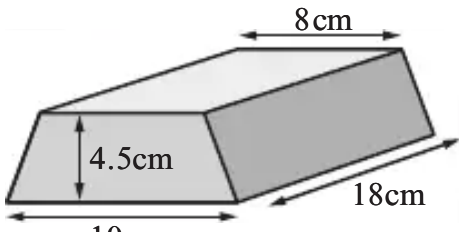


10 The diagram shows a bar of gold.

a Work out the volume of gold in the bar.

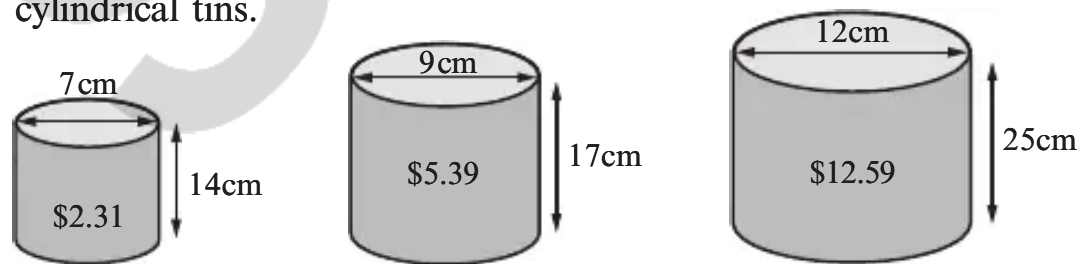
b 1 cm³ of gold has a mass of 19 grams. Work out the mass of the gold bar in grams.

c The value of gold changes with time. When Alicia



bought this bar of gold, the value of gold was \$35 per gram. She sold the bar of gold when the value of gold was \$42 per gram. How much money did Alicia make?

- 11 A shop sells chocolate drink powder in three different-sized cylindrical tins.



Which tin gives the best value for money? Explain your answer and show all your working.

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14 Volume, surface area and symmetry

14.2 Calculating the surface area of triangular prisms, pyramids and cylinders

Exercise 14.2

Focus

- 1 Copy and complete the workings to find the surface area of each pyramid.

- a Square-based pyramid (all triangles equal in size)

Square base: $10 \times 10 = \square \text{ m}^2$

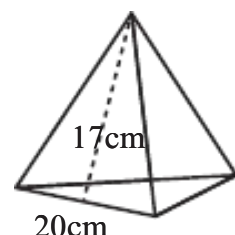
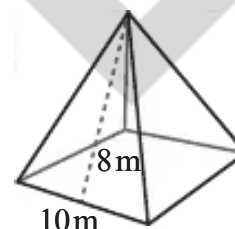
Triangular faces: $4 \times \left(\frac{1}{2} \times 10 \times 8 \right) = \square \text{ m}^2$

Total = $\square + \square = \square \text{ m}^2$

- b Triangular-based pyramid (all triangles equal in size)

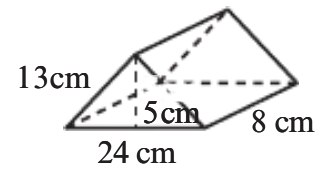
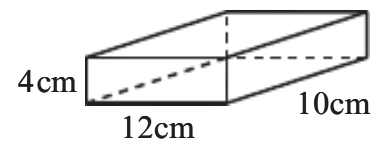
Each triangular face: $\frac{1}{2} \times 20 \times 17 = \square \text{ cm}^2$

Total = $4 \times \square = \square \text{ cm}^2$



- 2 Copy and complete the workings to find the surface area of each prism.

- a** Front and back: $2 \times (4 \times 12) = \square \text{ cm}^2$
 Sides: $2 \times (4 \times 10) = \square \text{ cm}^2$
 Top and base: $2 \times (12 \times 10) = \square \text{ cm}^2$
 Total $= \square + \square + \square = \square \text{ cm}^2$
- b** Triangle ends: $2 \times \left(\frac{1}{2} \times 24 \times 5 \right) = \square \text{ cm}^2$
 Sides: $2 \times (13 \times 8) = \square \text{ cm}^2$
 Base: $24 \times 8 = \square \text{ cm}^2$
 Total $= \square + \square + \square = \square \text{ cm}^2$

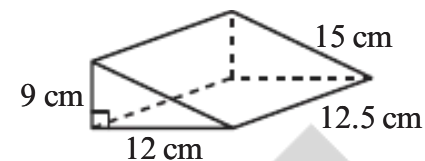


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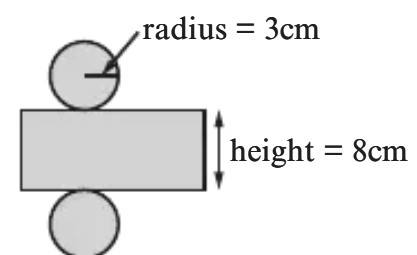
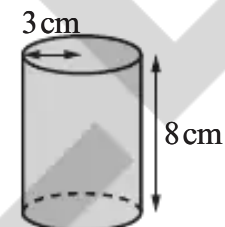
14.2 Calculating the surface area of triangular prisms, pyramids and cylinders

- c** Triangle ends: $2 \times \left(\frac{1}{2} \times 12 \times 9 \right) = \square \text{ cm}^2$
 Sloping face: $15 \times 12.5 = \square \text{ cm}^2$
 Back face: $9 \times 12.5 = \square \text{ cm}^2$
 Base: $12 \times 12.5 = \square \text{ cm}^2$
 Total $= \square + \square + \square + \square = \square \text{ cm}^2$



- 3** Copy and complete the workings to find the surface area of this cylinder.

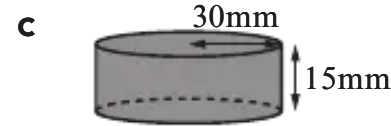
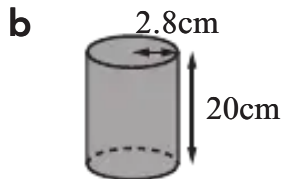
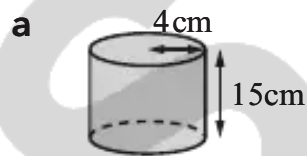
- Area of circle $= \pi r^2$
 $= \pi \times 3^2$
 $= \square \text{ cm}^2$ (2 d.p.)
- Circumference of circle $= \pi d$
 $= \pi \times \square$
 $= \square \text{ cm}$ (2 d.p.)
- Area of rectangle $= \text{circumference of circle} \times 8$
 $= \square \times 8$
 $= \square \text{ cm}^2$ (2 d.p.)
- Total area $= 2 \times \text{area of circle} + \text{area of rectangle}$
 $= 2 \times \square + \square$
 $= \square \text{ cm}^2$ (3 s.f.)



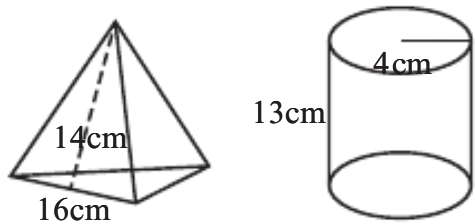
Practice

- 4** Work out the surface area of each cylinder. Give your answers correct to one decimal place (1 d.p.)

decimal place (1 d.p.).



- 5 The diagram shows a tetrahedron and a cylinder. Which shape has the greater surface area? Show your working.



Tip

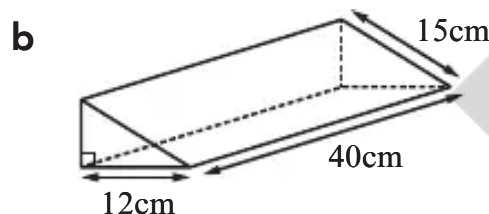
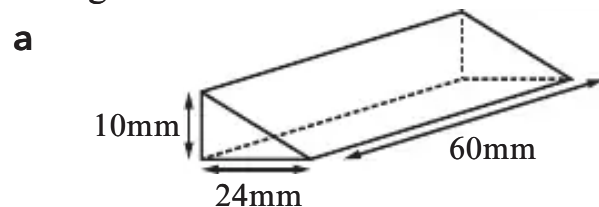
Remember: in a tetrahedron, all of the triangular faces are the same size.

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14 Volume, surface area and symmetry

- 6 The circular cross-section of a cylinder has a radius of 2 cm. The height of the cylinder is five times the radius. Work out the surface area of the cylinder correct to three significant figures.
- 7 Work out the surface area of these triangular prisms. The triangular cross-section of each prism is a right-angled triangle.

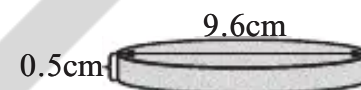


Tip

You will need to use Pythagoras theorem in this question.

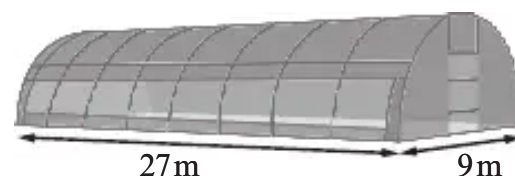
Challenge

- 8 The diagram shows a cylindrical rice cake. 18 of these rice cakes are stacked on top of each other in a cardboard tube. The tube has a cardboard base and a plastic lid.

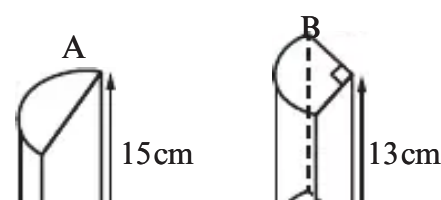


What is the surface area of the cardboard needed to make the tube? Give your answer correct to three significant figures (3 s.f.).

- 9 The diagram shows a polytunnel which is used to grow plants. The polytunnel has a semi-circular cross-section, and is made from plastic. Carlos thinks that 445 m² of plastic will be enough to make this polytunnel. Is Carlos correct? Explain your answer. Show all your working.

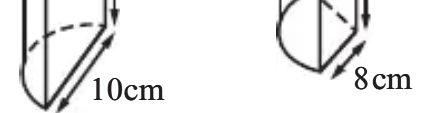


- 10 The diagram shows two prisms, A and B. The cross-section of prism A is a semicircle. The cross-section of prism B is a quarter-circle.



- a Without doing any calculations, which prism do you

- think has the greater surface area?
- b** Work out if your answer to part **a** was correct.
- c** Show that the difference between the surface areas of the two prisms is approximately 8 cm^2 .



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14.3 Symmetry in three-dimensional shapes

> 14.3 Symmetry in three-dimensional shapes

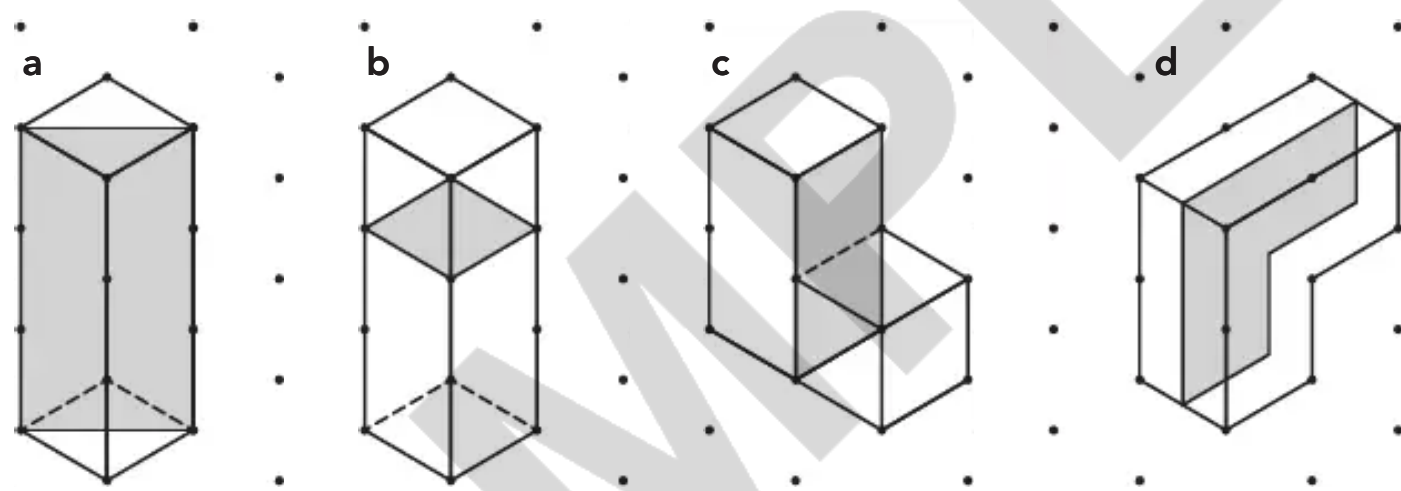
Exercise 14.3

Focus

Key words

plane of symmetry

- 1** The diagram shows some 3D shapes. Artur has drawn a **plane of symmetry** on each shape. He has drawn only two of the planes of symmetry correctly. Which two planes of symmetry has he drawn correctly?



- 2** Here are six prisms, A to F.



Write the letters of the prisms which have

- a one plane of symmetry
- b two planes of symmetry
- c three planes of symmetry.

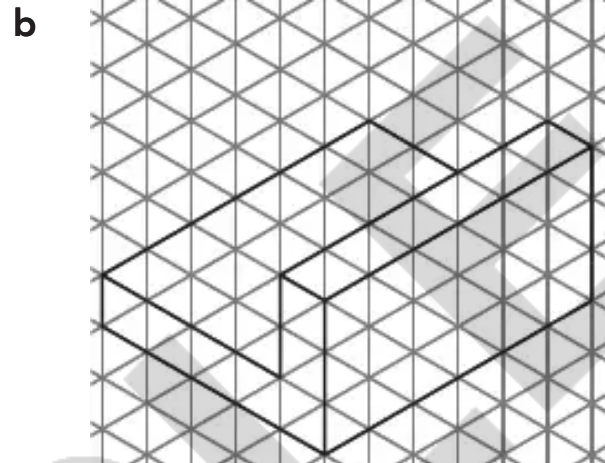
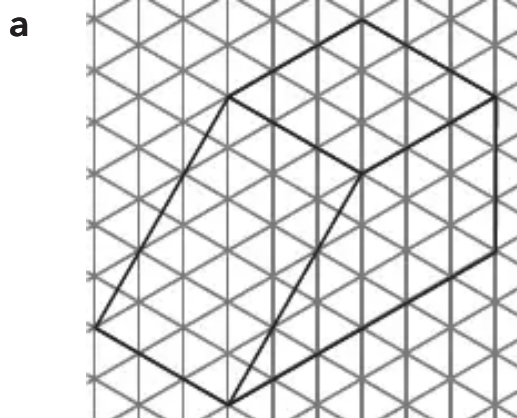
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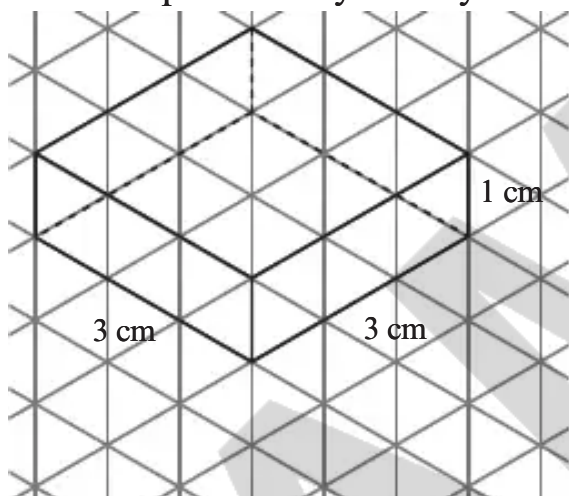
14 Volume, surface area and symmetry

Practice

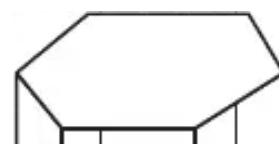
- 3 Each of these shapes has one plane of symmetry. Copy the diagrams and draw the plane of symmetry on each shape.



- 4 This is a cuboid. It has five planes of symmetry. Draw diagrams to show the planes of symmetry.



- 5 The diagram shows a 3D shape.
- a Describe the planes of symmetry for this shape.



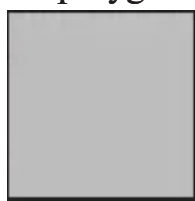
b Copy the shape and draw on the planes of symmetry.



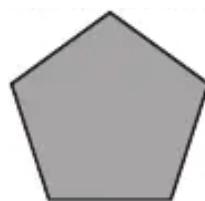
6 Here are some regular polygons.



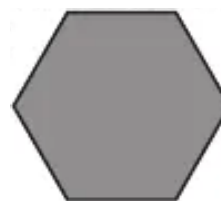
Equilateral triangle



Square



Pentagon



Hexagon



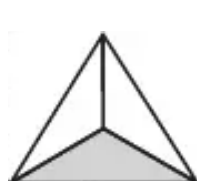
Octagon

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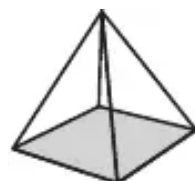
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14.3 Symmetry in three-dimensional shapes

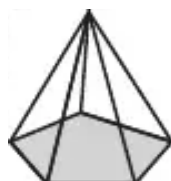
Each of the regular polygons is made into a pyramid as shown.



Triangular Pyramid



Square Pyramid



Pentagonal Pyramid



Hexagonal Pyramid



Octagonal Pyramid

a Copy and complete this table.

2D regular polygon	Number of lines of symmetry	3D pyramid	Number of planes of symmetry
triangle		triangular	
square		square	
pentagon		pentagonal	
hexagon		hexagonal	
octagon		octagonal	

b What is the connection between the number of lines of symmetry of a regular 2D polygon and the number of planes of symmetry of its matching 3D pyramid? Explain why this connection occurs.

c Use your answer to part b to write the number of planes of symmetry of a regular

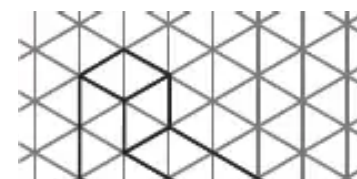
- i decagonal pyramid ii dodecagonal pyramid.

Tip

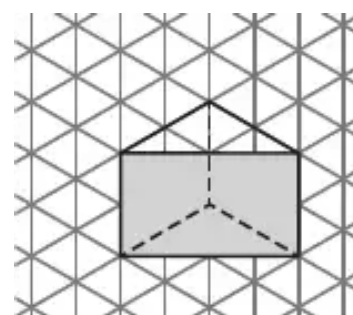
A decagon has 10 sides and a dodecagon has 12 sides.

Challenge

7 This is an isometric drawing of **half** a three-dimensional shape. The shaded face is on the plane of symmetry.



- a Draw the whole shape.
- b How many other planes of symmetry does the completed shape have?
- c Draw all the planes of symmetry on your diagram.
- 8 This is an isometric drawing of half a shape. The shaded face is on the plane of symmetry.
- a Draw the whole shape.
- b What is the name of the whole shape?
- c How many planes of symmetry does the whole shape have?



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15 Interpreting and discussing results

> 15.1 Interpreting and drawing

frequency polygons

Exercise 15.1

Focus

- 1 The table shows the time it takes for 45 students to complete a puzzle.

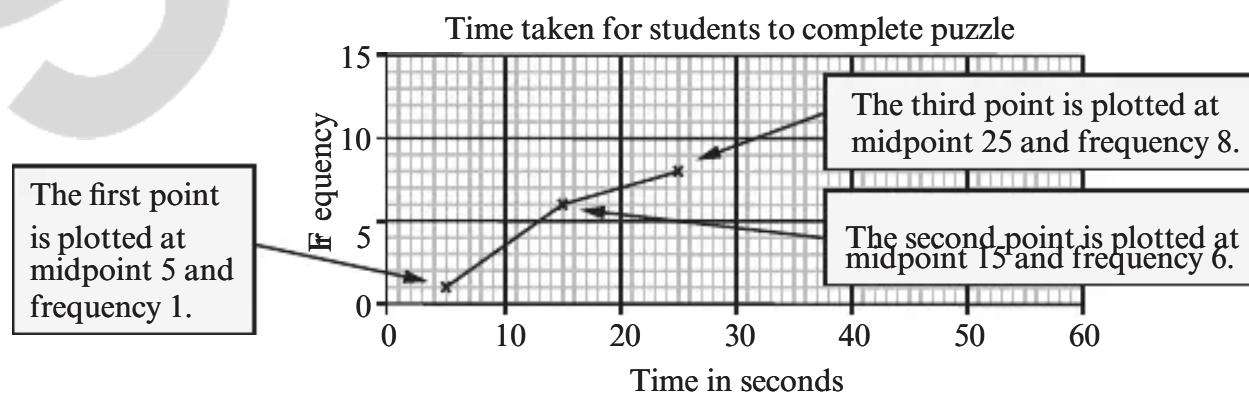
Time, t (seconds)	Frequency	Midpoint
$0 < t \leq 10$	1	5
$10 < t \leq 20$	6	15
$20 < t \leq 30$	8	25
$30 < t \leq 40$	11	
$40 < t \leq 50$	14	
$50 < t \leq 60$	5	

The **midpoint** is the number halfway between the lower and upper values of the class. Halfway between 0 and 10 is 5.

Key words

frequency
polygon
midpoint

- a Copy and complete the table.
- b Copy and complete the **frequency polygon** for this data.



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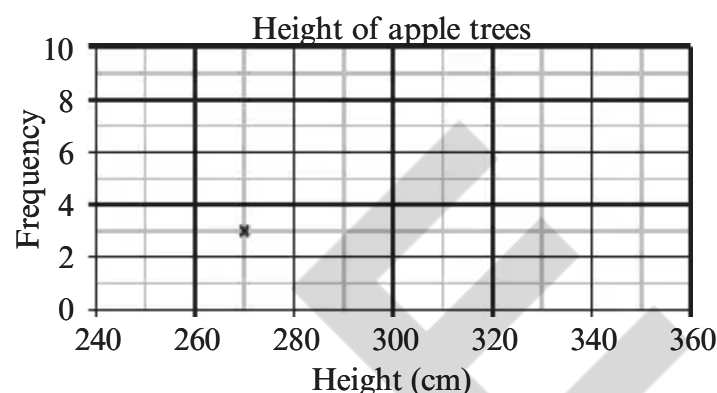
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15.1 Interpreting and drawing frequency polygons

- 2 The table shows the heights of twenty apple trees.

- a Copy and complete the table.
- b Copy and complete the frequency polygon.

Height, h (cm)	Frequency	Midpoint
$260 \leq h < 280$	3	
$280 \leq h < 300$	7	
$300 \leq h < 320$	9	
$320 \leq h < 340$	1	



Practice

- 3 The table shows the times taken by the students in class 9C to complete a cross-country run.
- a How many students are there in class 9C?
- b Copy and complete the table.
- c Draw a frequency polygon for this data.
- d What fraction of the students took less than 14 minutes to complete the run?
- e Zara says:

Time, t (minutes)	Frequency	Midpoint
$10 \leq t < 12$	4	
$12 \leq t < 14$	16	
$14 \leq t < 16$	7	
$16 \leq t < 18$	5	

The frequency polygon shows that the fastest student took 11 minutes to complete the run.



Is Zara correct? Explain your answer.

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15 Interpreting and discussing results

- 4 Twenty people recorded the time, in seconds, it took them to throw a double six with two dice. Here are the results.

21	6	40	29	32	15	25	37	28	15
12	30	18	35	22	45	30	9	17	23

- a Copy and complete this frequency table using the data provided.

Time, t (seconds)	Tally	Frequency	Midpoint
$0 < t \leq 10$			
$10 < t \leq 20$			
$20 < t \leq 30$			
$30 < t \leq 40$			
$40 < t \leq 50$			

- b Draw a frequency polygon to show the data.

- 5 Mia completed a survey on the heights of people going on a roller-coaster ride at a theme park on two days. The tables show the results of her survey.

Wednesday		
Height, h (cm)	Frequency	Midpoint
$120 \leq h < 140$	4	
$140 \leq h < 160$	6	
$160 \leq h < 180$	22	
$180 \leq h < 200$	18	

Saturday		
Height, h (cm)	Frequency	Midpoint
$120 \leq h < 140$	25	
$140 \leq h < 160$	16	
$160 \leq h < 180$	7	
$180 \leq h < 200$	2	

- a How many people were surveyed on each day?
- b Copy and complete the tables.
- c On the same grid, draw a frequency polygon for each set of data.

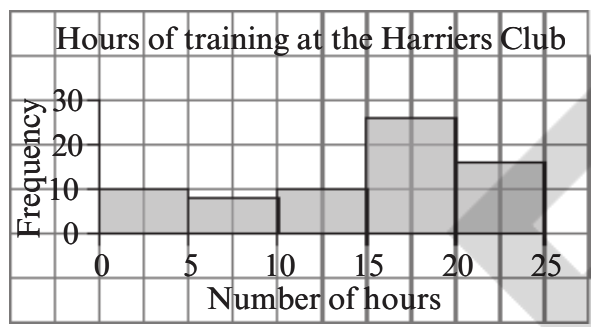
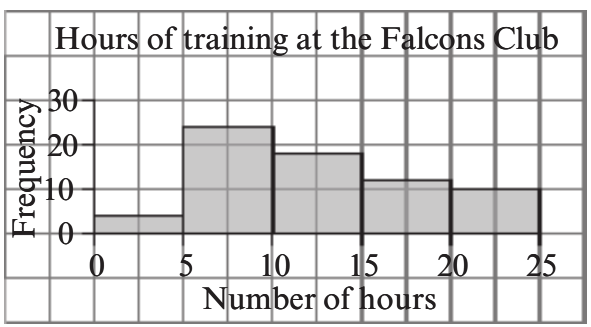
- c On the same grid, draw a frequency polygon for each set of data.
Make sure you show clearly which frequency polygon represents which day.
- d Compare the two frequency polygons. What can you say about the heights of the people on the roller-coaster ride on the two days?

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15.1 Interpreting and drawing frequency polygons

- 6 Harsha completed a survey on the number of hours that the athletes from two different clubs spend training each week.

The frequency diagrams show the results of her survey.



- a On the same grid, draw a frequency polygon for each set of data.
- b Compare the two frequency polygons. What can you say about the number of hours that the athletes from the two clubs spend training each week?
- c How many athletes from each club were surveyed?
- d Do you think it is fair to make a comparison using these sets of data? Explain your answer.

- 7 The table shows the mass of 50 girls when they are 6 months old.

- a Draw a frequency polygon for the data in the table.
- b Lucia wants to draw a frequency table with fewer groups. She regroups the data, and draws the second frequency table shown here:
- i Copy and complete Lucia's frequency table.
- ii Draw a frequency polygon for the data in Lucia's table.

- c Compare your frequency polygons in parts a and bi. Which frequency polygon gives you better information on the mass of girls who are

Mass, m (kg)	Frequency
$7.0 \leq m < 7.1$	2
$7.1 \leq m < 7.2$	12
$7.2 \leq m < 7.3$	14
$7.3 \leq m < 7.4$	9
$7.4 \leq m < 7.5$	7
$7.5 \leq m < 7.6$	6

Mass, m (kg)	Frequency
$7.0 \leq m < 7.2$	
$7.2 \leq m < 7.4$	
$7.4 \leq m < 7.6$	

6 months old? Explain your answer.

- d Sienna wants to have more groups in her frequency table. This is the table she starts to draw:

- i How many groups will there be in Sienna's frequency table?
- ii Can Sienna complete her table, using the frequencies in the table at the start of the question? Explain your answer.

Mass, m (kg)	Frequency
$7.00 \leq m < 7.05$	
$7.05 \leq m < 7.10$	
$7.10 \leq m < 7.15$	
$7.10 \leq m < 7.25$	

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15 Interpreting and discussing results

Challenge

- 8 The time, in seconds, it took 60 students to solve a maths problem was recorded. Here are the results.

20 44 34 50 33 41 38 43 53 35 47 40 27 49 24
35 39 21 38 36 23 32 30 40 35 25 32 47 33 48
45 30 41 33 49 37 54 47 34 45 36 56 35 58 40
20 51 31 26 39 30 41 35 54 37 46 22 42 31 29

- a Copy and complete the grouped frequency table for this data. Decide on your own group intervals. (You do not need to use all the rows in the table.)

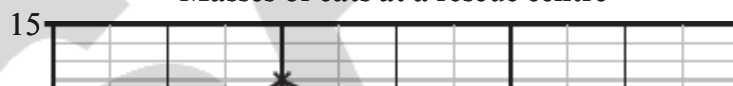
Time to solve maths problem, t (seconds)	Tally	Frequency	Midpoint

Tip

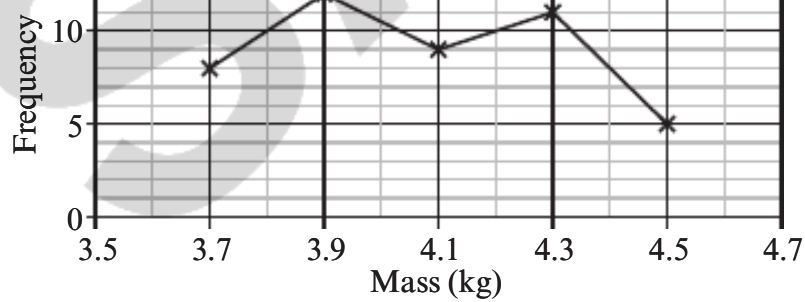
Find the quickest and slowest times first. This will help you to decide on the group intervals.

- b Draw a frequency polygon to show the data. Remember to include a title and to label the axes.
- c Make one comment about what your polygon tells you about the time it took the students to solve the puzzle.
- 9 The frequency polygon shows the masses of some cats at a rescue centre.

Masses of cats at a rescue centre



Mass, m (kg)	Frequency	Midpoint
----------------	-----------	----------



The heaviest cat has a mass of 4.58 kg. The range in the masses of the cats is 0.98 kg.

Copy and complete the frequency table.



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15.2 Scatter graphs

15.2 Scatter graphs

Exercise 15.2

Focus

- 1 The table shows the French and Spanish test results of 15 learners. Each test was marked out of 20.

Key words

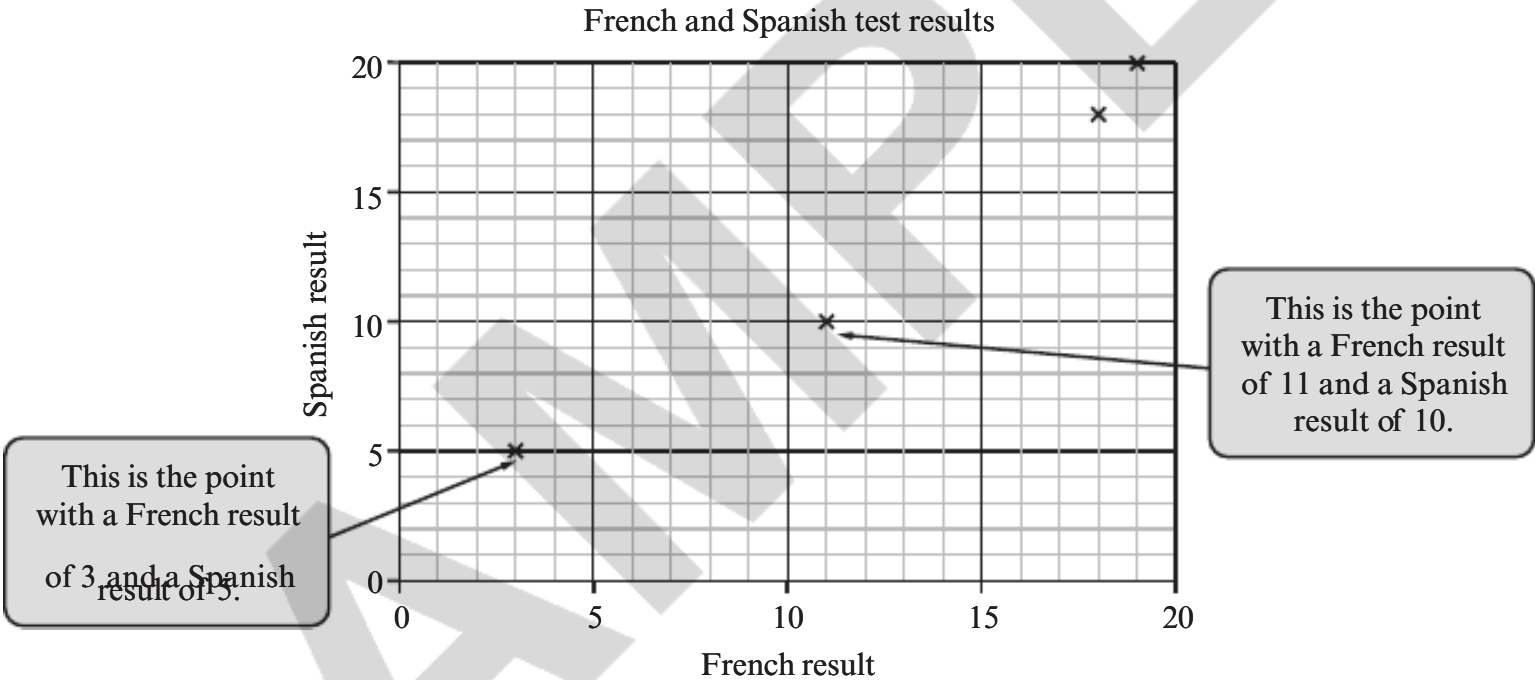
correlation

line of best fit

scatter graph

French result	3	11	18	19	5	20	14	8	9	7	5	16	10	9	16
Spanish result	5	10	18	20	6	18	16	9	11	6	5	15	11	7	16

The first four results have been plotted on this scatter graph.



- a Copy the scatter graph and plot the remaining points from the table. Mark each point with a cross. Check you have plotted all 15 points correctly. The points (11, 10), (18, 18), (19, 20), (5, 6), (20, 18), (14, 16), (8, 9), (9, 11), (7, 6), (5, 5), (16, 15), (10, 11), (9, 7), and (16, 16) are not plotted.

all the points by counting them. There should be 15 points altogether.

- b Which of these statements correctly describes the data on the scatter graph? Explain your answer.
- A The better learners do in the French test, the better they do in the Spanish test. Also, the worse learners do in the French test, the worse they do in the Spanish test.
- B The better learners do in the French test, the worse they do in the Spanish test. Also, the worse learners do in the French test, the better they do in the Spanish test.

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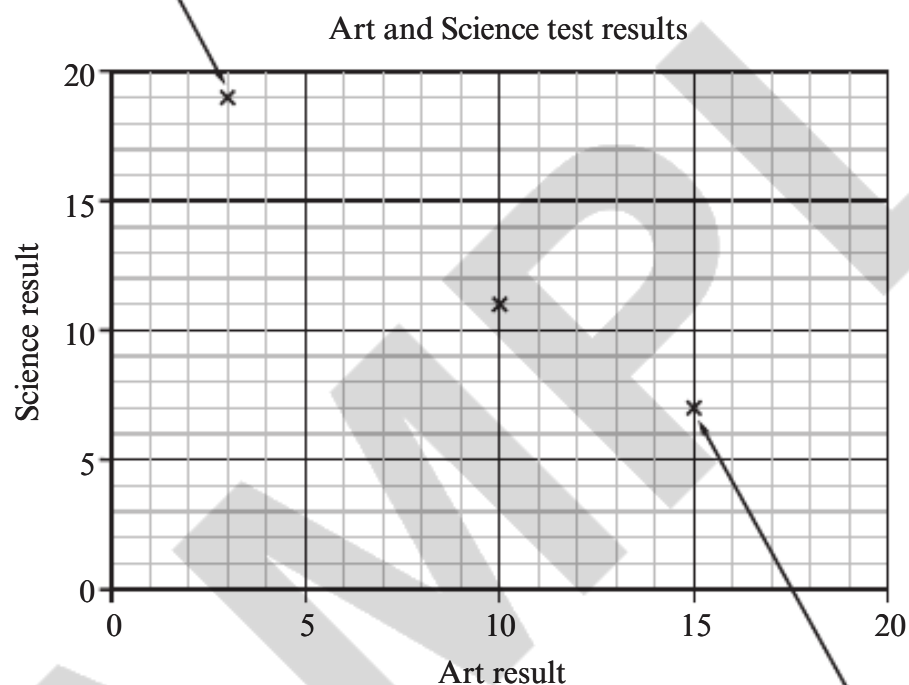
15 Interpreting and discussing results

- 2 The table shows the Art and Science test results of 15 learners. Each test was marked out of 20.

Art result	3	10	15	8	10	13	4	16	12	8	17	11	5	20	7
Science result	19	11	7	11	10	9	17	5	10	14	2	9	15	4	13

The first three results have been plotted on this scatter graph.

This is the point with an Art result of 3 and a Science result of 19



This is the point with an Art result of 15 and a Science result of 7

- a Copy the scatter graph and plot the remaining points from the table. Mark each point with a cross. Check you have plotted all the points by counting them. There should be 15 points altogether.

- b Which of these statements correctly describes the data on the scatter graph? Explain your answer.
- A The better learners do in the Art test, the better they do in the Science test. Also, the worse learners do in the Art test, the worse they do in the Science test.
- B The better learners do in the Art test, the worse they do in the Science test. Also, the worse learners do in the Art test, the better they do in the Science test.

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15.2 Scatter graphs

Practice

3

Maha carries out a survey of 15 learners in her class. She asks the learners how many hours a week they spend reading, and what they scored in a recent spelling test (out of 20).

The table shows the results of her survey.

Hours reading	4	13	20	9	18	1	11	8	18	2	15	10	4	14	7
Spelling test score	6	12	20	8	17	2	13	10	19	3	16	12	5	12	7

- a Draw a scatter graph to show this data. Draw each axis with a scale from 0 to 25. Take the horizontal axis as 'Hours reading' and the vertical axis as 'Spelling test score'.
- b What type of **correlation** does the scatter graph show?
- c Explain your answer.
Draw a **line of best fit** on your graph.
- d Maha reads for 12 hours a week. Use your line of best fit to estimate her score in the spelling test.

4

The table shows the number of packets of biscuits and the number of packets of crisps sold by a grocery store each day over a period of 10 days.

Number of packets of biscuits sold	15	12	26	22	8	25	16	14	9	28
Number of packets of crisps sold	12	22	14	7	28	27	25	18	17	25

- a Draw a scatter graph to show this data. Take the horizontal axis as 'Number of packets of biscuits sold' with a scale from 0 to 30. Take the vertical axis as 'Number of packets of crisps sold' with a scale from 0 to 30.
- b What type of correlation does the scatter graph show? Explain your answer.

5

The table shows the maths and drama exam results of 15 learners.

The results for both subjects are given as percentages.

Maths result (%)	72	34	81	57	32	78	65	67	53	61	35	42	55	79	31
Drama result (%)	27	62	19	41	66	25	37	32	59	48	63	59	40	35	77

- a Without looking at the values in the table, do you think there will be positive, negative, or no correlation between the maths and drama exam results of the learners? Explain your answer.

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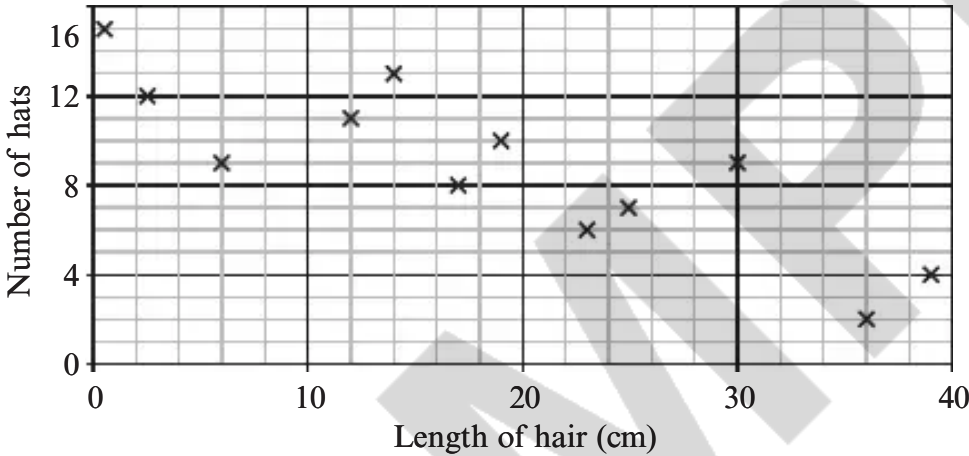
15 Interpreting and discussing results

- b Draw a scatter graph to show this data. Draw each axis with a scale from 0 to 100. Take the horizontal axis as ‘Maths result’ and the vertical axis as ‘Drama result’.
- c What type of correlation does the scatter graph show? Explain your answer.
- d Was your conjecture in part a correct?
- e Draw a line of best fit on your graph.
- f Use your line of best fit to estimate the drama exam result of a learner who scored 50% in their maths exam.

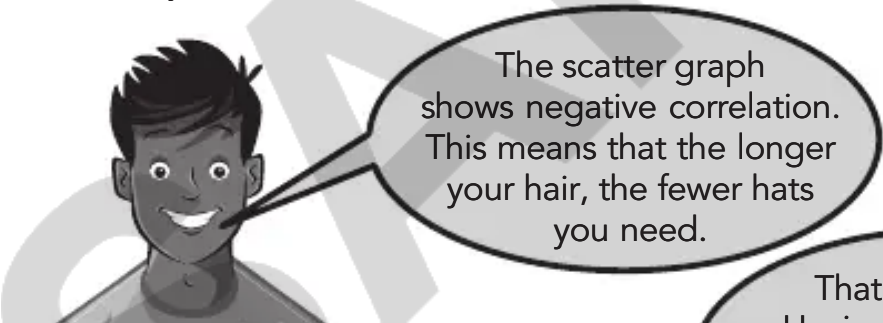


- 6 The scatter graph shows the number of hats bought in one year by 12 adults, and the length of their hair.

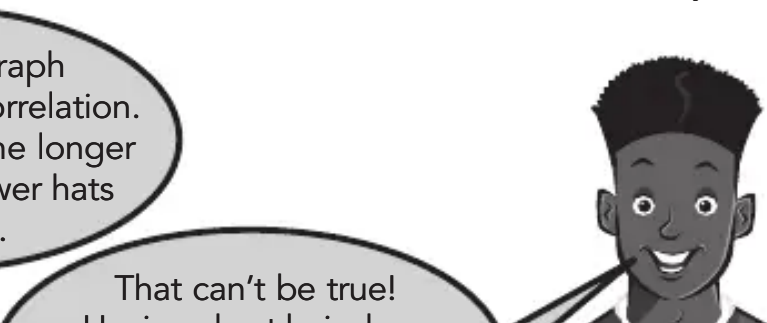
Number of hats bought in one year by 12 adults and the length of their hair



Arun says:



Marcus says:



Explain why Marcus is correct.

Having short hair does not mean you need more hats than someone with long hair.

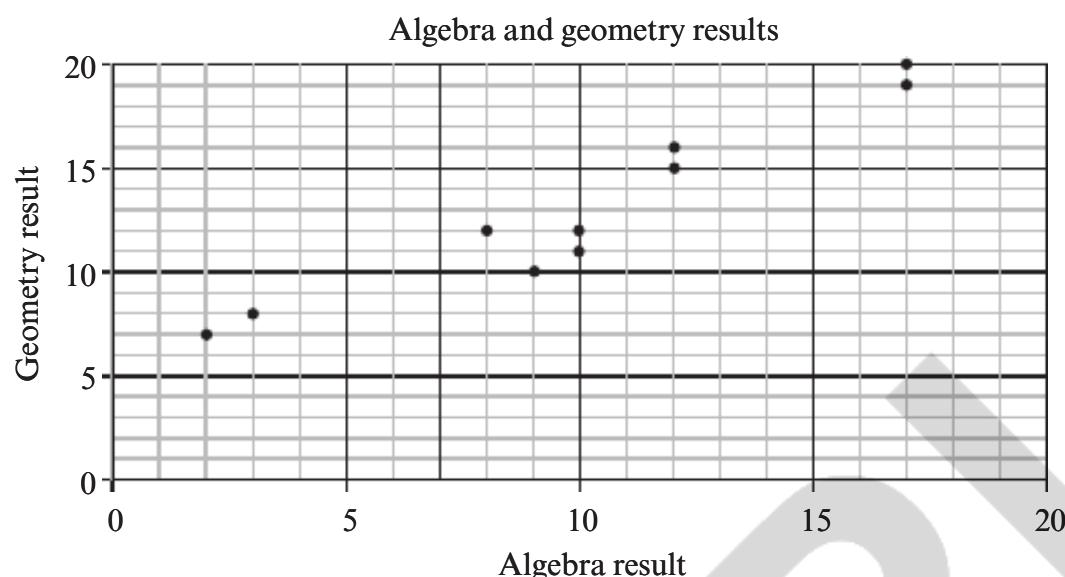
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15.2 Scatter graphs

Challenge

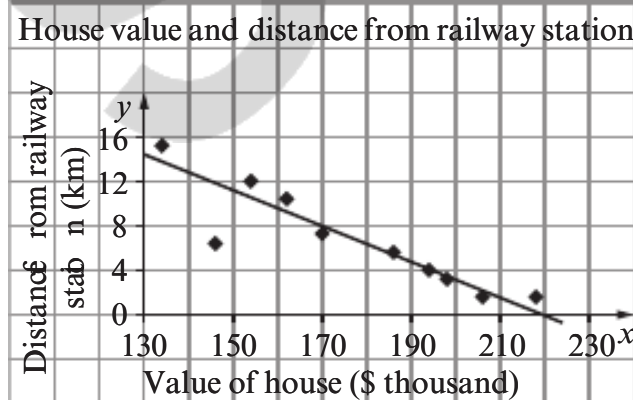
- 7 The scatter graph shows the algebra and geometry test results of 10 learners. Both tests were marked out of 20.



- What type of correlation does the scatter graph show? Explain your answer.
- Learners with a **total score** of more than 20 **do not** have to resit both tests. How many of the learners **do** have to resit both tests?
- Work out the mean algebra score.
- Work out the mean geometry score.
- Copy the scatter graph and plot the mean point with an X.
- Draw a line of best fit on your graph. Make sure your line goes through the mean point X.
- Use your line of best fit to estimate
 - the geometry score of a learner who scored 6 in algebra
 - the algebra score of a learner who scored 14 in geometry.

- 8 The scatter graph shows the value of two-bedroom houses in a town and the distance of the houses from the railway station

town and the distance of the houses from the railway station.



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- What type of correlation does the scatter graph show?
Explain your answer.
- One of the houses does not seem to fit the correlation.
Which house is this?
Explain why you think this house may be different from the others.
- A line of best fit has been drawn on the scatter graph.
What is the equation, in the form $y = mx + c$, of this line of best fit?
- Use your equation from part c to work out the value of y when $x = 180$.
Check your answer is correct by using the line of best fit.

15.3 Back-to-back stem-and-leaf diagrams

Exercise 15.3

Focus

- This table shows the results of a Spanish test taken by the learners in class 9R.

Spanish test results for class 9R									
15	14	26	16	5	22	25	10	18	21
22	27	7	23	9	17	20	19	9	24

- Copy and complete this unordered stem-and-leaf diagram

Key word

back-to-back
stem-and-leaf
diagram

Tip

The lowest result is 5 and the highest is 27. So, the stem must

Copy and complete this unordered stem-and-leaf diagram.
The first six entries from the table have been written on the diagram.

Key: 0 | 5 means 5

0 | 5
1 | 5 4 6
2 | 6 2

have:

0 for the results that are below 10

1 for the results that are between

10 and 19

2 for the results that are between 20 and 29

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15.3 Back-to-back stem-and-leaf diagrams

- b Copy and complete this ordered stem-and-leaf diagram to show this data.

Key: 0 | 5 means 5

0 | 5 7
1 | 0 4
2 | 0

Tip

You must write the leaves in order of size in each row of the diagram.

- 2 This table shows the results of a Spanish test taken by the learners in class 9T.

Spanish test results for class 9T									
18	12	21	6	8	28	4	11	14	21
20	6	17	13	19	28	21	10	12	22

Copy and complete the unordered and ordered stem-and-leaf diagrams.

Unordered:

Key: 0 | 6 means 6

0 | 6
1 | 8 2
2 | 1

Ordered:

Key: 0 | 4 means 4

0 | 4 6
1 |
2 |

- 3 Combine the two ordered stem-and-leaf diagrams from questions 1 and 2 to form a **back-to-back stem-and-leaf diagram**. The first row has been done for you.

Spanish test results for class 9R

Spanish test results for class 9T

9 9 7 5 | 0 | 4 6 6 8
1 |
2 |

Key for class 9R: 5 | 0 means 5

Key for class 9T: 0 | 4 means 4

For class 9R, copy the leaves from Question 1 part **b**, but write them in reverse order.

For class 9T, copy the leaves from the ordered stem-and-leaf diagram in Question 2.

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15 Interpreting and discussing results

Practice

- 4

The owner of a horse-riding school records the numbers of customers she has each day over a two-week period in June and a two-week period in August.

The tables show her results.

Number of customers during two weeks in June							Number of customers during two weeks in August						
43	37	45	68	39	20	43	47	55	62	38	36	50	43
40	60	46	42	46	41	46	54	37	58	40	58	52	56

- a

Draw a back-to-back stem-and-leaf diagram to show this data.
- b

For each month work out

i

the mode

ii

the median

iii

the range

iv

the mean.
- c

Compare and comment on the numbers of customers during June and August.
- d

The owner of the horse-riding school thinks she has more customers, on average, in August. Do you agree?

Explain your answer.
- 5

This back-to-back stem-and-leaf diagram shows the times taken by the learners in a stage 9 class to complete a word puzzle.

Girls' times							Boys' times						
6	5	5	4	2	1	9	24						
							25						3
							26			2	5	5	5
							27			1	3	5	6
							28			6	8	9	

Key: For the girls' times, 9 | 24 means 24.9 seconds

- a For each set of times, work out
 - i the mode
 - ii the median
 - iii the range
 - iv the mean.
- b Compare and comment on the times taken by the girls and the boys to complete the word puzzle.

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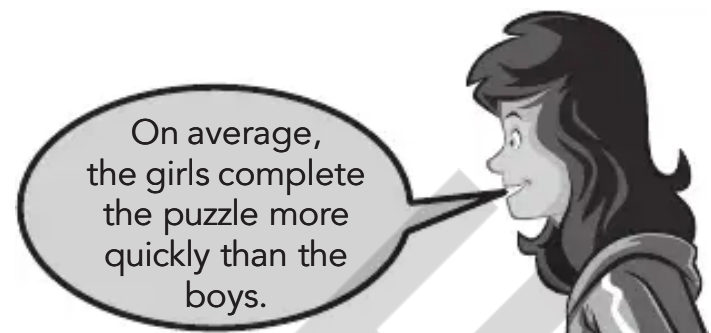
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15.3 Back-to-back stem-and-leaf diagrams

c Marcus says:



Sofia says:



- i Which average do you think Marcus is using?
- ii Which average do you think Sofia is using?
- d Who do you think completes the puzzle more quickly, the girls or the boys? Explain your answer.

- 6 The stem-and-leaf diagram shows the mass of potatoes grown per plant for 12 plants in two different locations.

Location A	Location B
80 65 40	25 40 55 75 90
90 90 75 55	30 75 85
90 45 25	45 55
45 10	05 20

Key: $40 \mid 6$ means 640 g Key: $5 \mid 25$ means 525 g

- a What fraction of the plants from each location had a mass of potatoes less than 700 g per plant?
- b What percentage of the plants from each location had a mass of potatoes greater than 825 g per plant?
- c Which location, A or B, had the most variation in the mass of potatoes grown per plant?
- d Work out the mean and median mass of potatoes grown per plant for each location.

- e Which location, A or B, do you think has the better conditions for growing potatoes? Explain your answer.

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15 Interpreting and discussing results

Challenge

- 7 The tables show the number of boxes of cereal sold in a supermarket each day over a two-week period, when the cereal was on display on the top shelf and on the middle shelf.

Top shelf						
109	125	128	112	119	126	104
112	127	129	122	130	124	120

Middle shelf						
120	142	139	145	127	115	139
136	129	144	130	147	132	138

- a Draw a back-to-back stem-and-leaf diagram to show this data.
- b Do you think sales of the cereal were better when the cereal was on the top shelf or on the middle shelf? Explain your answer clearly.
- 8 Oditi compares the heights of the learners in classes 9T and 9R. She draws this back-to-back stem-and-leaf diagram to show her results.

Oditi also calculates the mean, median, mode and range for each class. Unfortunately Oditi has spilt tea on her work!

Heights of class 9T											Heights of class 9R											
7	7	6	6	5	3	3	2	1	1		13	5	5	6	7	8	9					
			9	7	6		5	4	1	0	0	14	0	1	1	2	4	5		9	9	9
							7			2	2	15	0	0	1	7	8					
												16	0	1								

Key: 13 | 5 means 135 cm

	Range (cm)	Median height (cm)	Modal height (cm)	Mean height (cm)
Class 9T	33		152	
Class 9R	30	145		147

- a Work out the numbers under the tea stains

- a Work out the numbers under the tea stains.
- b Compare and comment on the heights of the learners in classes 9T and 9R.

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15.4 Calculating statistics for grouped data

> 15.4 Calculating statistics for grouped data

Exercise 15.4

Focus

- 1 The table shows the times taken by the 31 students in class 9G to complete a cross-country run.
- a Write down
- the modal class interval
 - the class interval where the median lies.
- b Work out an estimate for the range.

Time, t (minutes)	Frequency
$10 \leq t < 12$	7
$12 \leq t < 14$	12
$14 \leq t < 16$	10
$16 \leq t < 18$	2

Tip

Estimate for range = highest possible value – lowest possible value

- c Copy and complete the table and workings to find an estimate of the mean. Give your answer correct to the nearest minute.

Midpoint	Frequency	Midpoint \times frequency
11	7	$11 \times 7 = 77$
13	12	$13 \times 12 = \square$
\square	10	$\square \times 10 = \square$
\square	2	$\square \times 2 = \square$

Tips

The modal class interval is the class with the highest frequency. In this case, the highest frequency is 12.

There are 31 students altogether. The class interval containing the median will be the interval with the 16th fastest student.

<input type="text"/>	2	<input type="text"/> $\times 2 =$ <input type="text"/>
Totals:	31	<input type="text"/>

Estimate of mean = $\frac{\text{}}{31} = \text{}$ minutes

d Explain why your answers to parts b and c are estimates.

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15 Interpreting and discussing results

Practice

2 The table shows the heights of 20 pear trees.

- a Write
- i the modal class interval
 - ii the class interval where the median lies.
- b Explain why you can only give class intervals for the mode and median, and not exact values.
- c Work out an estimate for
- i the range
 - ii the mean.

Height, h (cm)	Frequency
$250 \leq h < 270$	4
$270 \leq h < 290$	5
$290 \leq h < 310$	8
$310 \leq h < 330$	3

3 The table shows the ages of the competitors in a marathon.

Age, a (years)	Number of men	Number of women
$20 \leq a < 30$	54	34
$30 \leq a < 40$	20	35
$40 \leq a < 50$	38	17
$50 \leq a < 60$	29	40
$60 \leq a < 70$	9	14

- a How many men and how many women ran in the marathon?
- b Copy and complete this table.

	Modal class interval	Class interval where the median lies	Estimate of mean
Men			
Women			

- c Compare and comment on the average age of the competitors in the marathon.
- d On average, who are the younger competitors, the men or the women? Explain your answer.

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15.4 Calculating statistics for grouped data

- 4
- Fabio records the number of text messages he sends each day for 20 days.
Here are the results.

25	7	18	8	5	17	27	8	19	22
19	12	8	20	16	10	14	12	15	30

- a
- Work out the mean, median and mode for this data.
- b
- Fabio decides to group the data. He is not sure which groups to use, so he draws two frequency tables.

Table A			Table B		
Number of texts	Tally	Frequency	Number of texts	Tally	Frequency
5 – 11			5 – 13		
12 – 18			14 – 22		
19 – 25			23 – 31		
26 – 32					

Copy and complete both tables for the data at the start of the question.

- c
- Copy and complete this table for each table in part b.

	Modal class interval	Class interval where the median lies	Estimate of mean
Table A			
Table B			

- d
- i

Compare the accurate mean in part a with the estimates you found in part c. What do you notice?

ii

Compare the accurate median in part a with the class intervals you found in part c. What do you notice?

iii

Compare the accurate mode in part a with the modal class intervals you found in part c. What do you notice?

- 5
- The table shows the ages of 40 people watching a rugby match.

Age, a (years)	Frequency
$0 < a \leq 10$	5
$10 < a \leq 20$	8
$20 < a \leq 30$	6

- a** Write
- i the modal class interval
 - ii the class interval where the median lies.
- b** Work out an estimate for
- i the mean
 - ii the range.

$20 < a \leq 30$	6
$30 < a \leq 40$	2
$40 < a \leq 50$	10
$50 < a \leq 60$	2
$60 < a \leq 70$	4
$70 < a \leq 80$	4

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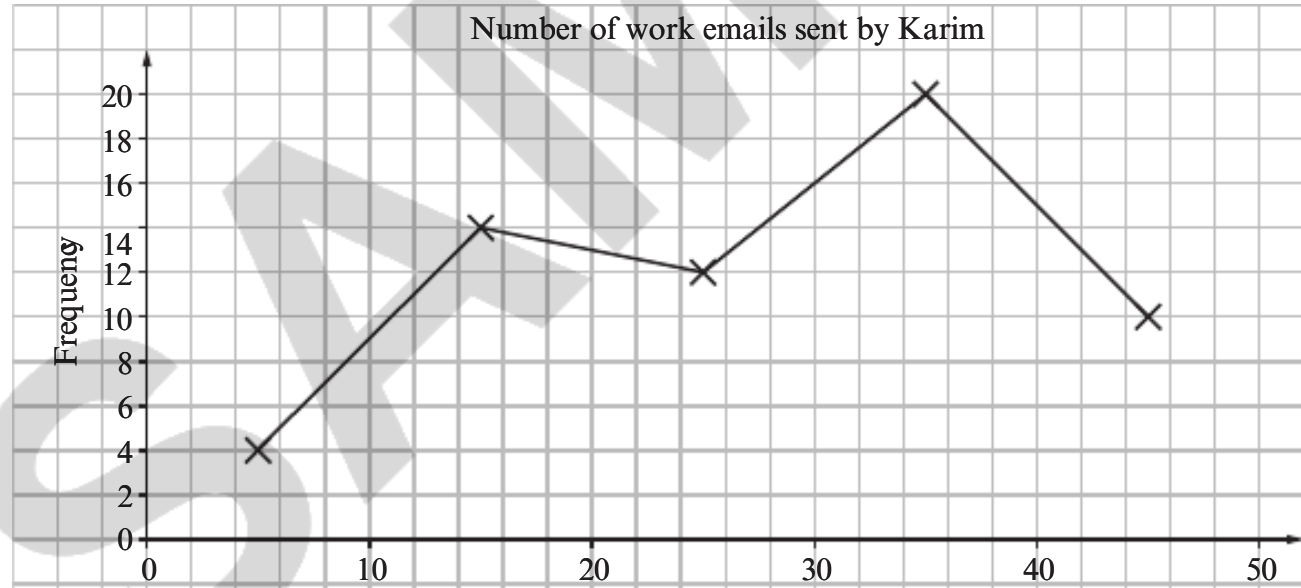
15 Interpreting and discussing results

- c** Henri decides to regroup the data, using larger group sizes.
Copy and complete his table.
- d** Write
- i the modal class interval
 - ii the class interval where the median lies.
- e** Work out an estimate for
- i the mean
 - ii the range.
- f** Compare your answers to parts **a** and **b** with your answers to parts **d** and **e**.
- i Do you think the answers to parts **a** and **b** or the answers to parts **d** and **e** are more accurate? Explain why.
 - ii Were the answers in parts **a** and **b** or the answers in parts **d** and **e** quicker to work out? Explain why.

Age, a (years)	Frequency
$0 < a \leq 20$	
$20 < a \leq 40$	
$40 < a \leq 60$	
$60 < a \leq 80$	

Challenge

- 6** The frequency polygon shows the number of work emails that Karim sends each day for 60 days.



Karim works out that an estimate of the mean number of emails he sends each day is 28.

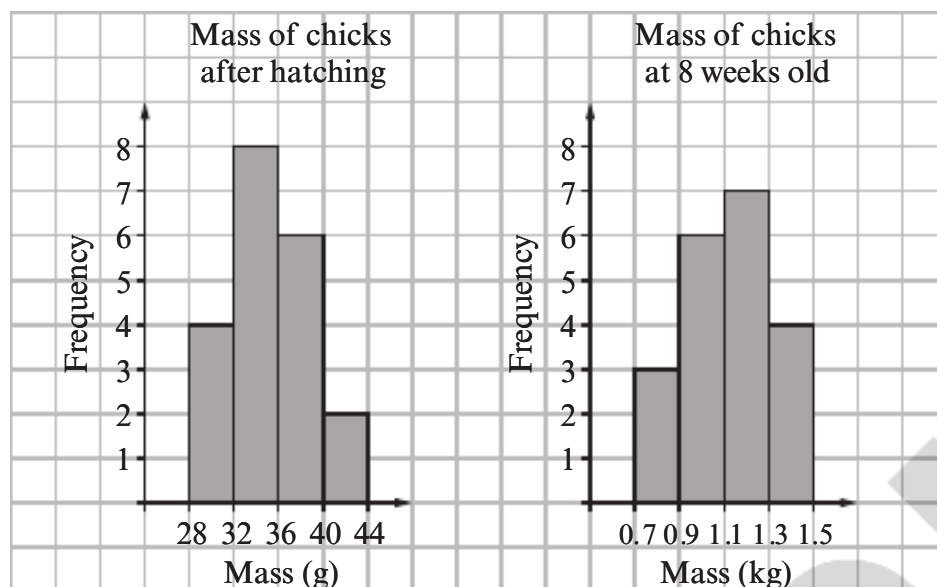
Is Karim correct? Show your working.

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15.5 Representing data

- 7 The frequency diagrams show the mass of 20 penguin chicks after hatching and at eight weeks old.



Show that the mean mass of the chicks at eight weeks old is more than 30 times the mean mass of the chicks after hatching.

> 15.5 Representing data

Project Australia!

In the following text, there are lots of facts, figures and tables giving you information about Australia. You can use this information to add some extra diagrams, graphs and charts to your poster.

This table shows the quality of accommodation used by tourists for short-stay holidays in five cities in Australia.

	Brisbane	Darwin	Melbourne	Perth	Sydney
Budget (1 & 2 star)	2%	8%	5%	3%	4%
Mid-scale (3 star)	29%	14%	18%	33%	20%
Up-scale (4 star)	59%	70%	60%	50%	54%

Luxury (5 star)	10%	8%	17%	14%	22%
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15 Interpreting and discussing results

Australia is home to the kangaroo. The kangaroo is the only large animal that travels by hopping. Kangaroos can reach a top speed of over 65 km/hour and can jump 3 m high and further than 7 m in length. There are four species of kangaroo: the Red, the Antilopine, the Eastern Grey and the Western Grey. Red kangaroos are the largest and can live around 12 to 18 years.

The table shows an estimate of the number of kangaroos in Australia every two years since 2008.

Year	2008	2010	2012	2014	2016	2018
Number of kangaroos (millions)	25	27	34	44	45	46

In 2019, it was estimated that there were two kangeroos for every person in Australia!



gettyimages

25 YEARS

Penny Tweedie

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